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THE UNITED STATES STEEL CORPORATION is the name selected for the new steel consolidation, the incorporation papers of which were filed in New Jersey on Feb. 25. The charter recites at great length the powers which the new corporation may exercise, and the whole may be concisely summed up by saying that it may do anything it pleases. The new corporation is to have a capitalization of $1,100,000,000, of which $300,000,000 will be in bonds, $400,000,000 in preferred stock and $400,000,000 in common stock. The properties to be absorbed thus far named are those of the Carnegie Steel Co., the Federal Steel Co., the American Steel & Wire Co., the National Tube Co., the National Steel Co., the American Tin Plate Co., the American Steel Hoop Co., and the American Sheet Steel Co.

THE MINERAL RESOURCES OF THE PHILIPPINES are discussed at some length in the report of the Philippine Commission, of Nov. 30, 1900. The mineral fields of the islands have never been thoroughly prospected, and have been little worked, even when known. The report states that about 1,200 prospectors and miners, mostly Americans, are now scattered over the islands and are rapidly reporting finds. In the Province of Lepanto, there are immense deposits of gray copper and copper sulphide intersected by gold-bearing quartz; the claim is made that the ore assays 8% copper. Lignites are known to exist in a number of the islands; and the extensive coal fields of Bulacacao are within 4 to 6 miles of a safe harbor and some of the Cebu deposits are also well situated as to harbor. Tests of this coal show that it does not clinker and does not clog the tubes as much as do the Japanese and Australian coals. Extensive deposits of iron ore are known to exist; but their development must be preceded by the working of the coal-fields. The great difficulty encountered at present by those interested in developing these mineral resources of the country is the absence of adequate mining laws; and the Commission recommends that immediate steps be taken in this connection. A tangled mass of concessions granted by the Spanish government must also be carefully overhauled before new concessions and mining rights can be established.

SUBMARINE CABLE LAYING, in various parts of the world, is likely to follow the present commercial development of several important nations. For the United States a Pacific cable and a direct cable to Porto Rico are inevitable. England also proposes to lay a Pacific cable, from Vancouver to Norfolk Island and thence to Australia and New Zealand. Including South African cables, the British plans are said to contemplate the expenditure of about $30,000,000 on 23,000 nautical miles of submarine cables. Germany wants an independent cable to her eastern colonies, and the Netherlands will unite with her in this enterprise. France is also agitating for French cables to points now controlled only by English lines.

THE MEXICAN PORTS OF COATZACOALCOS, on the Gulf of Mexico, and Saline Cruz, on the Pacific, are to be made available for commerce under a contract just made between President Diaz and the English firm of Pearson & Co. These ports are the terminals of the Tehuantepec Railway, now practically useless as a world's highway. The contractors are to receive $5,000,000 for putting the railway in repair and improving the Eastern harbor and providing an artificial harbor on the Pacific side. Further, for the first 35 years the Government is to receive only 62½% of the profits of operating the line, and 66% for the next 5 years; 70% for the next 5 years and 74% for the last 5 years of the 50-year concession.

THE U. S. SAMOAN COALING STATION in the harbor of Pago Pago, will be completed in about three months, according to Mr. Robert Tibbitts, the contractor, now in this country. The work includes a steel pier 365 ft. long and 80 ft. wide, founded on steel piles 9 ins. diameter and 30 to 70 ft. long; and a steel storage building, 150 ft. long by 100 ft. wide, at the land end of the pier. This building will hold 10,000 tons of coal. The total cost will be $400,000.

THE SUN'S TOTAL ECLIPSE OF MAY 17 is to be observed by an expedition sent by the Massachusetts Institute of Technology to Sumatra. The expedition is in charge of Prof. Alfred E. Burton, of the Civil Engineering Department, and he takes with him Mr. Harrison Smith, of the Department of Physics; Mr. George L. Hosmer, of the Civil Engineering Department, and Mr. G. H. Mathes, a graduate of '95 The first three named observed last summer's total eclipse of the sun. The Harvard authorities have loaned this party valuable instruments, and others were secured from the United States. The expedition sailed from New York on Feb. 23 to Genoa, where it will take a Dutch steamer to Padang, Sumatra, via the Suez Canal. The members expect to return by way of Singapore, Hongkong and San Francisco. The expense of the expedition is defrayed by private subscriptions, but principally from the income of the "Edward Austin Fund for scientific research."

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision on Feb. 21, between a section of the Atlantic City Express and an accommodation train, near Trenton, N. J., on the Camden & Amboy Division of the Pennsylvania R. R. Both trains were running at full speed, and the locomotives and first two cars of each train were completely destroyed. Thirteen bodies were recovered from the wreck, and others are believed to have been consumed in the accompanying fire; 40 or 50 persons were more or less seriously injured. The accommodation train was ordered to wait on a siding for the express, which was in three sections. Through a misunderstanding it left the siding after only two sections of the express had passed.——Six persons were killed and six seriously injured in a wreck of the San Francisco eastbound express on the Southern Pacific R. R., at Winnemucca, Nev., on Feb. 17. The train plunged at full speed into a chasm cut by a cloudburst in a deep fill.

THE STEAMER, "CITY OF RIO DE JANEIRO," of the Pacific Mail Steamship Co., struck a rock and foundered at the Golden Gate at the entrance to the harbor of San Francisco on Feb. 22. Of the 207 people on board, 128 were lost. The accident occurred during a dense fog and the ship sank within a few minutes in 36 fathoms of water. The "Rio de Janeiro" was launched in 1878, and was not provided with water-tight bulkheads, which accounts for her rapid sinking.

THE DAM OF THE ELECTRIC LIGHT PLANT at Thompsonville, Mich., broke on Feb. 18, drowning two men.

THE CASE AGAINST THE CARTER CONTRACTORS has been advanced another step. On Feb. 25, U. S. Commissioner Shields in New York city decided there was "probable cause" for the indicted parties to be removed to Savannah for trial; the next step will be an application to Judge Brown of the U. S. District Court for the issuance of a warrant for such removal. The following condensed chronology shows the law's delay in bringing the Carter contractors to trial:

1897, August 14. Discovery of Irregularities in Savannah Harbor work reported to Chief of Engineers.
1897, Dec. 2. Court Martial of Carter ordered.
1898, Jan. 12 to April 30. Court Martial of Carter held.
1899, Oct. Findings of Court Martial approved by President.
1899, Dec. 8. Federal Grand Jury at Savannah indicted Greene, Gaynor and others for conspiring with Carter to defraud the Government.
1899, Dec. 23, to 1900, Feb. 3. Hearings before Commissioner Shields on application for removal of indicted parties to Savannah for trial.
1900, Feb. 10. Commissioner Shields decided that probable cause for removal existed.
1900, Feb. 13. Application to Judge Brown for warrant for removal.
1900, April 4. Judge Brown denied application on the ground that Commissioner Shields' excluded evidence tending to show guilt or innocence of accused.
1900, July to December. Hearing before Commissioner Shields on new application for removal of indicted parties.
1901, Feb. 25. Commissioner Shields' decision rendered.

THE FIRST WATER FILTER BEDS for Philadelphia will be built by D. J. McNichol, of that city, for $229,083, including a clear-water basin. The plant will be known as the lower Roxborough. The work must be completed in five months.——A contract for a 1,000,000-gallon filter plant for the Philadelphia city hall will be awarded, it is expected, to the Maignen Filtration Co. for $19,000, including operation for three years. This company was the only bidder for the city hall work.——A contract for $669,633 worth of water mains has been awarded to Mr. McNichol.

AN ELECTROLYSIS SUIT AT FRANKLIN, O., has been brought by the village against the Southern Ohio Traction Co. The village alleges that the company has violated an ordinance prohibiting the passage of electricity from the wires of the company to and through the water mains of the village. Damage to the amount of $5,000 is asked. P. H. Rue is attorney for the village.

AN ORDINANCE TO PREVENT ELECTROLYSIS at Battle Creek, Mich., was passed last fall. It requires all electric street railway companies to install and maintain metallic return circuits of such a character that the difference of potential between such circuits and any water or gas pipe shall not exceed ¼ volt and so that not over one ampere of current shall be passed through any such pipe. In the future, overhead construction must be used unless the franchise for new work expressly provides to the contrary. The ordinance contains many other points of probable interest to water-works and gas men. Copies of it may be secured, we presume, by addressing the Board of Public Works, Battle Creek, Mich. Mr. W. W. Brigden is engineer and superintendent of the water-works at Battle Creek.

THE IMPEDANCE OF IRON CONDUCTORS carrying alternating currents is discussed by Herren C. Feldmann and J. Herzog in an article which appeared recently in the Elektrotechnische Zeitschrift. They give some results of experimental determinations of the impedance of iron conductors of various forms of cross-section, including steel rails, since the latter would probably be used as one of the circuits in any system of electric traction. It was found that with a peaked wave of electro-motive force the impedance was much greater than with a sine wave. The power factor for the rails in all cases was in the neighborhood of 0.8. With a frequency of 42 cycles per second, the impedance was 5.25 times, and with a frequency of 15, 3.6 times, as great as the resistance to continuous currents.

DAMAGES FROM VIBRATION, caused by trains on the Central London underground railway, amounting to $21,000, were sued for by Dr. Purves, a physician of Oxford St., London. In the London Sheriff's Court, the jury awarded Dr. Purves £1,500, or $7,500. The exact nature of the injuries is not stated, other than that they were due to the construction of the railway.

PUBLIC IMPROVEMENTS IN CHICAGO have received a check by a decision from the Supreme Court of Illinois holding that the limit of bonded indebtedness has already been reached. In the anticipation of a favorable decision projects had been prepared involving an aggregate expenditure of $46,250,000, none of which can now be carried out. The proposed expenditures included $2,500,000 for developing the water power of the Drainage Canal, $1,000,000 for lowering the tunnels under the river, $2,000,000 for electric light plants, $2,000,000 for small parks, $10,000,000 for a subway system for street cars, and $5,000,000 for new bridges. The allowable limit of bonding is 5% as the assessed valuation, which would be $13,830,000 on the valuation of $276,000,000. The municipal officers claimed that the limit should be 5% of the fair cash value of the property, which is five times the assessed value. This view the court rejects. The actual bond issues of the city, however, already aggregate $16,330,000 (or about $2,500,000 in excess of the legal limit), while the actual indebtedness amounts to $26,330,000.

THE IMPROVEMENT OF NEW YORK TENEMENTS is recommended by the Tenement House Commission, which has been investigating this subject for about one year. In a report dated Feb. 25, the Commission says that there are 82,652 tenement houses in the Greater New York; 42,700 in Manhattan; 33,771 in Brooklyn, and over 4,000 in the Bronx. They estimate that over 1,585,000 people of this city are housed in tenements. They define the present type of a tenement house as a six-story "double-decker" occupying 75% of a 25 ft. lot; with four families on a floor. These buildings give less ventilation, light, fire protection and general comfort than did the tenements of 50 years ago. The Commission recommends that no light shaft shall be less than 4 ft. wide; no backyard shall be less than 12 ft. deep; all windows must open on the street, backyard or open court; there shall be no dark hallways; every apartment must have a separate toilet room, with access to it by some other way than through a bedroom; ample fire escapes must be provided, and in all tenements the first story must be fireproof. As a remedy to existing evils they recommend a separate department with the sole duty of supervising tenement house construction and maintenance and enforcing tenement house laws. This work is now divided between the Health Department, Department of Buildings and Fire Department. The law, if made, would apply to all cities of the first class in New York state.

REMOVAL OF SOME SUBMERGED WATER MAINS, AT CHELSEA, MASS.

By Caleb Mills Saville, Assoc. M. Am. Soc. C. E.*

Of the systems of water pipes recently acquired from the city of Boston by the Metropolitan Water Board of Massachusetts, two very interesting portions have recently been removed and are now being replaced by other structures. In one case, a larger main is being laid, a portion of which will have joints similar to the Ward's flexible joint, and in the other case a brick tunnel is being built, in which will be laid a line of 24-in. cast-

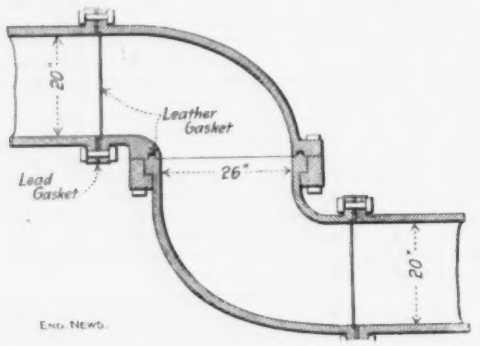

Fig. 1.—Section of a Flexible Joint for Submerged Pipe, Designed Some 50 Years Ago.

iron pipes of the ordinary pattern. The tunnel is circular in section, and has an inside diameter of 6 ft.

The first section to be removed was one of the two mains running under Chelsea Creek, from Chelsea, for the supply of East Boston. At this point, Chelsea Creek is a tidal estuary about 1,425 ft. wide at high water; while at low water the channel is about 650 ft. wide. The average range of the tides is about 10 ft., and at the point of crossing there was a maximum depth of 25 ft. of water. The bottom of the stream is covered with about 2 ft. of river mud overlying a stratum of firm clayey material. On either side of the channel a stretch of mud flats is exposed at low water, over which the pipe, raised slightly above the level of the mud, was supported on piling. This foundation consisted of bents of two spruce piles, each 8 or 9 ft. c. to c., and capped with heavy timbers of various sizes. Across the channel the pipes were laid on the bottom of an apparently dredged trench, and the tops of the pipes were 5 or 6 ft. below the bottom of the river bed. This main was laid in 1850, and had a nominal inside diameter of 20 ins. All of the pipes were very badly tuburculated; in some cases a solid mass 1 in. in thickness entirely lining the inside of the pipe.

On removing the pipe, that portion which was under water all of the time and covered with clay was found to be in excellent condition, and local iron founders were very desirous to obtain it, offering $3 per ton more for it than for other scrap-iron. Above low water the iron of the pipes had badly deteriorated, a black mark sharply defining the sound iron from that of poorer quality. The outside of this portion had become softened to the consistency of hard graphite. It was readily cut into for ¼-in. with an ordinary pocket-knife, and in buying this pipe the foundry men deducted 40% of its weight.

Above low water the pipes were ⅞-in. thick and had ordinary bell and spigot joints, poured with lead. These pipes were about 9 ft. long. They were unprotected, and only covered by the tide at high water. In removing them the line was broken every two pipe lengths by heavy hammers and bursting wedges, at low water, and chains attached to ropes were put around the pipe. At high water, a large scow, rigged with winches and derricks, was pulled alongside, and the several pieces pulled aboard, and later landed at the wharf of a near by iron foundry. Below low water the pipes were 1¾ ins. thick, 9 ft. long, but had flanged joints. Where the pipe had been wholly protected from the action of the water, even the heads of the bolts, and the nuts and the flanges were well preserved; and the corners were as sharp as when first laid, the nuts being readily turned from the bolts by use of a wrench. When the pipes had not been covered with clay, the flanges, bolts and nuts, were badly corroded. This portion of the line was composed of a succession of offsets, each made up of three straight pipes with flanged joints. At each end of these sections was a flexible joint of most peculiar pattern, which made a right-angled horizontal offset in the pipe line. This special was composed of three parts, put together in such a manner that the joint was perfectly flexible vertically. It was able to accommodate itself to any irregularities of the bottom, and if necessary a section of the pipe, if free at one end, could be made to describe a complete revolution. Horizontally, the joint was as stiff as any flanged joint. Fig. 1 shows this joint and the other flanged joints adjacent. On the flange at each end of the special, and on each end of the middle one of the three straight pipes of each section, was a rectangular lip, at right angles to the face of the flange. This lip was ¾-in. wide and ½-in. deep; its inner side being a prolongation of the inside of the pipe. On the flanges of the other two straight pipes at each end, and in position corresponding to the lip, was a rectangular groove ¾-in. wide and ¼-in. deep. The joint was probably made up in this way: First, a thin leather gasket covered with white lead was placed in the groove, and the flanges brought together, the lip being entered into the groove. On account of the gasket, and also from the fact that the lip was longer than the groove, the flanges would be separated a little more than ¼-in. The bolts were then put in—14, each 1¼ ins. in diameter—and strain enough put on to force the lip hard against the gasket. The lead was then poured into the space between the flanges, filling the space fully, and in some cases even running into the holes around the bolts, where they fitted loosely. The flanges were 3 ins. deep and 2 ins. thick. The leather gaskets were in excellent condition, the fiber being strong and firm. The special joint was made on the same principle, and consisted of three parts. One end of each of the two main parts, where they joined the straight pipe sections, had a nominal diameter of 20 ins. This was gradually increased to 26 ins. at the other end, where they joined each other. The 20-in. end of each portion of the special had a flange with a lip, as previously described, for joining with the flanges on the straight pipe. On the 26-in. end of one portion, also, was a flange with a groove, while on the 26-in. end of the other portion was a lip. The flange of the first portion was 6 ins. deep and bored for 18 1¼-in. bolts; the flange of the second portion was 3 inches deep and had 36 holes. Over the flange of the second portion the third part was fitted. This was a heavy circular ring of rectangular section, except that a section was taken out of one of the inner corners sufficient to allow this ring to fit easily over the flange in the second portion. This ring had holes to correspond with those in the flange of the first portion. By referring to Fig. 1, it is readily seen that the ring bolted to the flange of the first portion unites both first and second portions firmly and also on account of the rebate in the ring the second portion can readily turn around the axis of the special at this point, but cannot make any angle with it. In putting the special together, the ring was too small to slip over the flange on the 20-in. end; so this flange was turned down about ½-in., and after the ring had been put on, a wrought-iron band was shrunk onto the flange to restore its original depth. Fig. 2 shows some of these joints and pipes as they lay on the wharf after removal. The band shrunk on the end of the special is plainly shown, and a portion of the lead gasket appears in some of the bolt holes. The tuberculation in the pipe is also shown, while the perfect condition of the edges of both nuts and flanges is worthy of note, considering that they have laid in the bottom of the river for 50 years. In removing the submerged portion of the line, the pipe was first uncovered so far as possible by a dredge with an orange peel bucket. This work was made somewhat difficult by the fact that the supply of water to East Boston had to be maintained during the work through a line of 24-in. pipe, parallel with and less than 15 ft. in some places from the line being removed. On this account the dredge had to work at right angles to the pipe line to avoid driving the spuds through the live pipe. That this portion of the work was accomplished without accident was due to the expert manner in which the dredge was handled by her captain. After as much as possible of the material over the pipe had been removed, a large wrecking lighter was brought to the work. At one end of this boat was a pair of hard pine shears about 70 ft. high and 20 ins. in diameter at the butts. Attached to the shears were two wire rope falls, one rive through two 5-part blocks and the other through 4-part blocks. Each of these falls was capable of being operated independently by the hoisting machinery. In raising the pipe, one of the falls would be attached by a diver near the free end of the pipe by wire slings and shackles, and as a strain was applied.

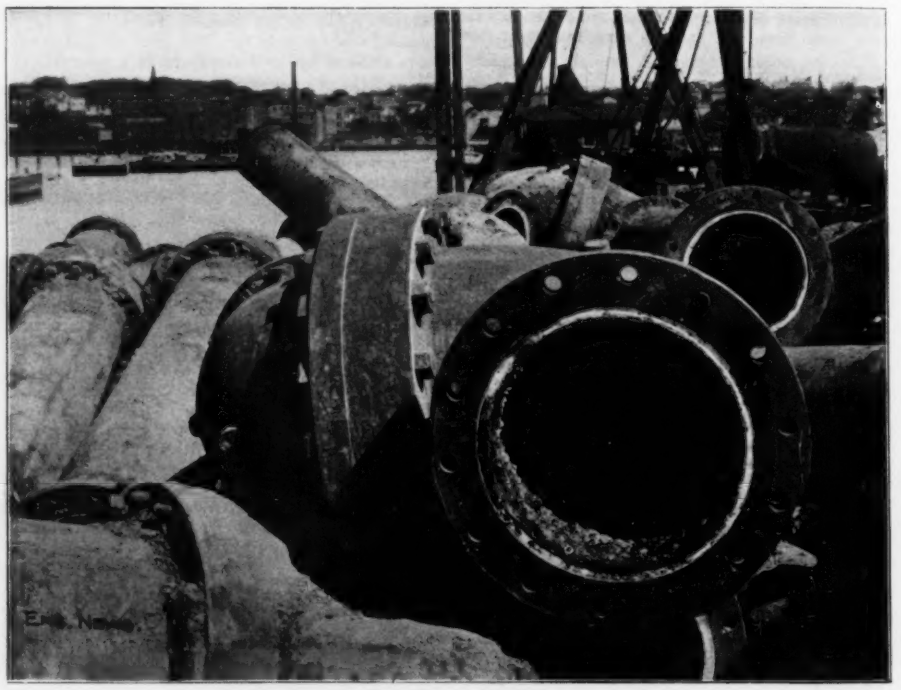

FIG. 2.—VIEW OF FLEXIBLE JOINT IN OLD 20-IN. SUBMERGED PIPE UNDER CHELSEA CREEK.

*Division Engineer Distribution Department Metropolitan Water Board, Boston, Mass.

the flexible joint in the bottom of the river would turn, so that the portion of the pipe to which the sling was attached would rise to a nearly vertical position. Hoisting would be continued until about three pipe lengths were exposed, when the other falls would be attached below the lowest exposed joint. This joint would then be unbolted and the free section placed in a near by scow. The process would then be repeated, the second sling raising the pipe, and the first holding the next section when it was raised high enough. Several times the pipe itself broke in the raising, and once one of the wire slings parted, letting the pipe back into the river. At these times a diver was sent down and the slings re-attached. On the East Boston side of the river the pipes were laid on platforms or cradles, each about 2 ft. wide and 7 ft. long, made of square timber, laid lengthwise of the pipe. In this cradle the outside timbers were of 8 × 8-in. stock and the others of 4 × 4-in. stock. They were fastened to the pipe by U-shaped hangers of round iron, ¾-in. in diameter.

The second section of the pipe lines to be removed was at Chelsea North Bridge, over the Mystic River, between Boston and Chelsea. On account of widening and deepening the channel at this point, two inverted siphons, through which water had previously been supplied to Chelsea and East Boston, were removed by the city. The siphons were in the shape of three sides of a parallelogram, and consisted of cast-iron pipes, one 24 and the other 30 ins. in diameter, surrounded with concrete and the whole encased in a box of heavy timber, securely bolted together. One side of the box was horizontal and lay embedded in the river bottom; the other two sides were vertical and stood on either side of the channel and were joined to other portions of the pipe lines laid on the bridges. The distance between the vertical portions of the siphons was about 50 ft., and the top of the horizontal portions was about 37 ft. below the pipes on the bridge, and about 23 ft. below low water.

The boxes were rectangular in section, one being 5.3 × 4.5 ft. and the other being 4.2 × 3.9 ft. A dredge was employed to uncover the horizontal portions. When this was done the wrecking lighter, previously described, and a powerful pile-pulling scow were attached, one at each of the upright portions of the 24-in. siphon, by means of heavy chains and wire ropes. The work of fastening the chains to the siphon was begun at 2.30 p. m. and the siphon was floated out of the channel and landed on a beach exposed at low water at 3.15 p.m. The 30-in. siphon was not so easily removed. The dredge had mangled it somewhat, and the bottom was not in such good condition as was the other. The uprights pulled off from the horizontal portion and were loaded separately. A diver then passed a steel wire through the pipe remaining at the bottom. To the wire a small rope was attached and to this a wire rope was tied. The ends of the wire rope, after being pulled through the pipe, were brought together above water and fastened to the hoisting gear of the pile puller. The pipe was then hoisted out, strung like beads on the wire rope, and the bottom of the box was removed later. Both pipes were badly tuberculated, their diameters being reduced from 2½ to 4 ins. by a solid incrustation on the inside of the pipes. The 30-in. pipes were of Scotch make, ⅞-in. in thickness, and having joint room 6½ ins. deep and ⅜-in. wide, run solid with lead. In the inner and outer surfaces of these pipes the iron was almost black in color and softened to a depth of ¼-in. to the consistency of graphite. The remaining ⅝-in. in the center of the pipe wall was light gray in color, coarse in texture, and several of the pieces examined were defective. The 24-in. pipes were made by the Warren Machine & Foundry Co. in 1863, were ¾-in. in thickness and had joint room 3 ins. deep, also filled solid with lead. The iron in these pipes was apparently of much better quality than that in the 30-in. pipes. It was fine grained and no defects in any of the pieces examined were noticed. Although exposed to the tubercles on the inside and rust on the outside none of the discoloration noticed in the 30-in. pipe was found and the iron was firm and solid to the edges of the pipe wall. In both siphons the concrete in the upright portions was badly disintegrated, but that in the bottom of the 24-in. box was in excellent condition and was made from cement, sand and gravel stones. The lower two-thirds of the horizontal portion of the smaller box had evidently been embedded in the clayey material in the bottom of the channel and was in excellent condition, the spruce timbers being sound and bright when cut into and even the gager's marks were plainly visible. Between the bottom of the channel and low water, the woodwork was almost wholly destroyed on the uprights and the top of the horizontal portion of the box, probably by the limnoria. Between high and low water, the woodwork had deteriorated, as might be expected, from decay and weather. The heads of the bolts, the nuts and washers which were below water all of the time, but not covered with clay, were badly decomposed, the laminated structure of the iron showing plainly, and so soft that a pocket-knife was easily forced ½-in. into the side of a 2-in. nut. At the bottom, when wholly protected by the clayey covering, the nuts and bolts were for the most part in excellent condition. In all cases where the nut was not wholly destroyed it would readily turn from its bolt, the threads of which would be as bright and sharp as when first made. In the 30-in. siphon the bolts in the uprights were of copper and were in perfect condition in every way and could have been used again if carefully removed. Below low water and the bottom of the river bed this box was sheathed with copper, beneath which the wood was in excellent condition, presenting a marked contrast to that in the 24-in. box, which was so badly damaged, although built many years later. The bottom of the 30-in. siphon was put together with iron bolts, was not copper sheathed, nor had it been buried deeply in the river bottom. Not only were the bolts almost wholly destroyed, but the box itself was almost destroyed by the limnoria. The 30-in. siphon was laid in 1850 and the 24-in. siphon about 14 years later.

Mr. Frederic P. Stearns, M. Am. Soc. C. E., is Chief Engineer, and Mr. Dexter Brackett, M. Am. Soc. C. E., is Engineer of the Distribution Department of the Metropolitan Water Board.

THE GOKTEIK VIADUCT; BURMAH RAILWAYS, LTD., BURMAH.

(With two-page plate.)

The Gokteik Viaduct is one of the most notable bridge structures erected by American bridge builders in foreign countries since the construction of the great Hawkesbury Bridge in Australia in 1889. This structure crosses a deep and wide gorge on the Rangoon-Mandelay line of the Burmah Railways; is 2,260 ft. long, and 320 ft. high, and required 9,703,831 lbs., or 4,852 tons of steelwork for its construction. Its main dimensions and weight compared with those of other notable structures of corresponding type are as follows:

Name and location.	Length, ft.	Height, ft.	Metal, tons.
Loa Viaduct, Bolivia	800	336	1,115
Pecos Viaduct Texas	2,180	320′ 10¾″	1,820
Gokteik Viaduct, Burmah	2,260	320	4,852
Old Kinzua Viaduct, Pennsylvania	2,052	301	1,750
New Kinzua Viaduct, Pennsylvania	2,053	301	3,350

As will be seen, the Gokteik is exceeded in height by the Loa and the Pecos viaducts, but it exceeds in length and weight of material used all others, the nearest approach to it in length being made by the Pecos Viaduct, and the nearest approach in weight by the new Kinzua Viaduct. It may be noted also that with the exception of the Loa Viaduct, which was built by English engineers, all of these structures are of American construction.

The Gokteik Viaduct is located on the top of a ridge which crosses a deep valley on the Mandelay-Rangoon line at a point about 400 miles from Mandelay. The top of this ridge is, however, some 300 ft. below the level of the banks of the valley, and this space was required to be filled with a structure rising to the height of the grades of the railway approaches on the opposite banks. The consulting engineers of the Burmah Railways, Sir Alexander Rendel & Co., of London, England, after the usual preliminary negotiations, awarded the contract for the detail design, construction and erection of this structure to the Pennsylvania Steel Co., of Steelton, Pa., Mr. J. V. W. Reynders, Superintendent Bridge and Construction Department. Mr. W. H. Clark represented the consulting engineers at the works of the Pennsylvania Steel Co., and there supervised the detail design of the viaduct and the manufacture of the steelwork for it. With comparatively few exceptions American precedents were followed in both design and methods of workmanship.

Fig. 1 is a diagram elevation of the viaduct. As will be seen, it consists of 14 single towers, one double tower and a rocker bent, which, with the abutments, carry ten 120-ft. truss spans and seven 60-ft. plate girder spans. In plan the viaduct for 281 ft. at one end and 341 ft. at the other end is curved to a radius of 800 ft., and between these two curves there is a tangent of 1,638 ft. The height of the structure above the ground is 130 ft. at one end, 320 ft. at the highest point, and 213 ft. at the other end. The viaduct was designed to carry a double track of 1 m. (3.28 ft.) gage and a footwalk, but the floor system for the footwalk and one track, only, is constructed at present.

TOWERS.—As will be seen from Fig. 1, the single towers consist of two transverse trestle bents braced together in all directions. The double tower consists of three trestle bents. So far as was practicable, that is, except for the bottom stories, which had to be arranged to conform to the ground surface, the members of all bents were made interchangeable. Fig. 2 shows the details of the tower construction in full, and no further explanation is necessary here. The tower strains were computed for: (1) Both tracks fully loaded; (2) one track fully loaded; (3) one track unloaded, and (4) one track loaded with 1,120 lbs. per lineal foot. The full track load was assumed at 1,712 lbs. per lineal foot; a single track and its girders were assumed to weigh 706 lbs. per lineal foot. The wind load was taken at 33.6 lbs. per lineal foot. Referring to Fig. 2, it will be seen that the columns of each bent are connected transversely of the bridge at their tops by a plate box girder. The longitudinal connections between tops of columns are plate girders resting directly on the cap plates of the columns.

CONNECTING SPANS.—Except for seven plate girder spans, located at the ends of the viaduct, all of the connecting spans are made up of two 120-ft. deck trusses. These trusses carry 27-in. plate girder floor beams spaced 13 ft. apart, which in turn support the track stringers. The top flanges of the trusses, floor beams and stringers are made flush and are covered over with a solid floor of 5-16-in. flat plates. This floor beam and stringer construction is somewhat modified in the plate girder end spans, but the plate flooring is made continuous over them and the towers. The connecting span and floor construction conforms throughout to usual good practice in such work, but calls for no other mention.

METHOD OF ERECTION.—Perhaps the most interesting part of the work was the methods adopted in preparing the material for shipment and for erection by unskilled workmen in a location far from any adequate base of supplies. The first task was, of course, to prepare the steelwork and to collect the necessary plant and supplies. Before leaving the shop the various members were painted in various colors and combinations of colors which enabled the men in charge of erection, by means of a suitable key drawing, to locate by its color the position of each member in the structure. The erecting plant included as its most important parts a steel traveler; an air compressor with pneumatic riveters and reamers; three four-drum hoisting engines; four derricks, and a supply of tool steel and small duplicate parts. The miscellaneous supplies included a photographer's outfit, medical supplies, a field telephone system, etc.

All material was delivered at track grade at one end of the structure, and erected from this point by means of the traveler. This traveler is shown in several of the accompanying half-tone views, and as will be seen, was of the standard type usually employed for viaduct erection in the United States. It consisted of two parallel cantilever trusses 219 ft. long and 40 ft. deep, spaced 24½ ft. apart center to center, and firmly braced together, the whole being mounted on a braced girder tower 20 ft. high. On the lower chords of the traveler there ran four trolleys, each provided with a 16-

ton differential chain hoist. The overhang of the cantilever portion of this traveler was 166 ft., so that it easily spanned the spaces from tower to tower. The heaviest loads handled by the traveler were the 120-ft. trusses, which weighed 22 tons each. The total counterweight used was 136,000 lbs., and the total weight of the steelwork in the traveler was 180,000 lbs.

The details of the erection work varied but little from those usual to the same class of work in America, except that native workmen had to be employed and managed. About 500 persons altogether were employed. For the information from which this description has been prepared we are indebted to the Pennsylvania Steel Co., of Steelton, Pa.

AN INEXPENSIVE GAGE FOR USE WITH THE VENTURI METER.

By Charles P. Paulding.*

The gage described in this note was devised by Capt. Henry Metcalfe for use with a Venturi water meter at the water-works of Cold Spring, N. Y., Capt. Metcalfe being the President of the Water Board. The Venturi tubes, made by the Builders Iron Foundry, of Providence, R. I., are too well known to need any description, their application to the metering of water having been fully described some years ago by Mr. Clemens Herschel, M. Am. Soc. C. E.† The makers furnish with them, when desired, an elaborate and very perfect apparatus for recording the quantity of water passing through the meter.

No charge is made to the village of Cold Spring by the owners of the water rights unless the village uses more than 60,000 gallons per day. As

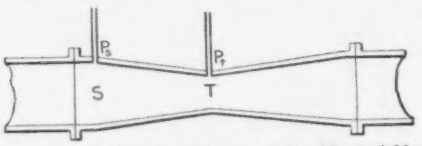

Fig. 1.—Illustrating the Theory of the Venturi Meter.

this amount is considerably in excess of the present needs of the village, and as there is no reason for measuring the water so long as the limit is not exceeded, it seemed unwise to the president of the water board to expend very much money on a recording apparatus for the meter. He therefore had constructed the simple gage hereinafter described. Furthermore, the rates of flow which he particularly wished to measure were so slow that he required extreme sensitiveness in the gage without any very large range of capacity.

Before passing to the description of the gage it may be as well to give briefly the theory of the Venturi tube itself. Its action as a water meter depends on the fact that in a level pipe filled

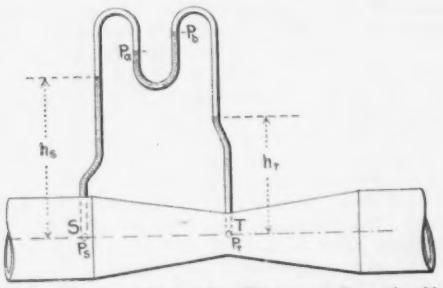

Fig. 2.—Diagram Illustrating Theory of Gage for Use with the Venturi Meter.

with flowing water the sum of the pressure head and the velocity head is constant at all points. Considering the points S and T (Fig. 1) we have:

$$\frac{P_s}{12} + \frac{V_s^2}{2G} = \frac{P_t}{12} + \frac{V_t^2}{2G}.$$

Where V = velocity in ft. per sec. and Ps and Pt the head in inches of water at the points S and T. The area at T is some known fraction of the area at S. Let us say that it is $\frac{1}{d}$ times the area at S.

*600 River St., Hoboken, N. J.
†Trans. Am. Soc. C. E., Vol. XVII., p. 228.

Then

$$V_t = d\,V_s.$$

Substituting and transposing we have:

$$\frac{d^2 V_s^2 - V_s^2}{2G} = \frac{(P_s - P_t)}{12} \text{ and } V_s = 8.05\sqrt{\frac{(P_s - P_t)}{12\,(d^2-1)}}.$$

We know the value of d to begin with and the gage hereinafter described gives us the value of

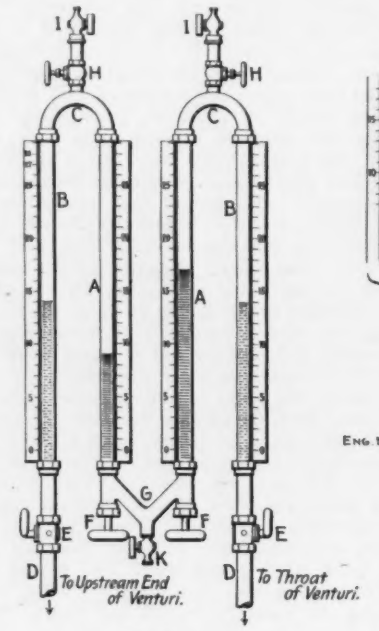

Fig. 3.

Ps — Pt in inches of water. We can then solve the equation and find the velocity of the water in the pipe line. Knowing the size of the pipe we can now find the quantity of water passing through the meter in any given time.

The gage for finding the difference Ps — Pt is shown diagrammatically in Fig. 2. Its actual construction is shown in Fig. 3. A A are glass tubes which, with the casting G, form an ordinary U-tube. The leaden bends C, C, join this U-tube to the two glass tubes B, B, which are respectively joined to the throat and full sized portion of the Venturi by the leaden pipes D, D.

The glass tubes B, B, are for the purpose of observing the level of the water in the two outer pipes, the necessity for which will be shown later, F F are valves which are used to prevent the colored water in the U-tube from being driven over the bends during violent fluctuations of the flow through the Venturi. The globe valves H, H, and the pet cocks I, I, form air locks by means of which the height of the water in the outer columns can be regulated with great nicety. K is a pet cock through which the U-tube can be emptied or filled with colored water with the aid of a rubber bag and tube. E E are valves for opening up connection with the Venturi. When the connection with the Venturi is closed these valves drain off the water above them from the outer tubes. It will, of course, be understood that when the instrument is in operation there is no connection with the atmosphere, the bends and the upper parts of the glass tubes being filled with air under pressure.

The principle of the gage, which is, I believe, somewhat novel, may be shown as follows: Represent by Ps and Pt the heads in inches of water at the points S and T and by Pa and Pb the heads on the surface of the liquid in the U-tube. Now, as previously shown, we wish to measure the difference between Ps and Pt. At first sight it might appear that Pb — Pa was the desired quantity, but evidently Pa is less than Ps by the head of water hs; and Pb is less than Pt by the head of water ht; and therefore Pa — Pb can only equal Ps — Pb when hs = ht.

Algebraically we have:

$$P_a = P_s - h_s \qquad (1)$$

and

$$P_b = P_t - h_t.$$

Then

$$P_s - P_t = (P_a - P_b) + h_s - h_t).$$

In other words, the true reading of the gage is the difference of level of the liquid in the U-tube plus the difference of level of the water in the outer tubes. This latter difference must be subtracted from the reading of the U-tube when the water stands higher in the T-tube than in the S-tube.

Figs. 3, 4 and 5 show three apparently differe

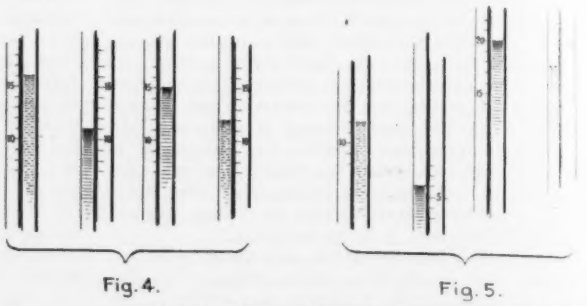

Fig. 4. Fig. 5.

FIGS. 3-5.—GAGE FOR USE WITH THE VENTURI METER.

readings of the gage for the same rate of flow in the Venturi:

For Fig. 3 the reading is 8 + 0 = 8.
" " 4 " " " 4 + 4 = 8.
" " 5 " " " 14 − 6 = 8.

In calibrating the gage the above method was followed as a check, the different readings being obtained by manipulating the air locks at the top of the bends. The gage was calibrated by noting with a stop watch the time necessary to fill a 205.7-gallon tank with various rates of flow. Several readings of the gage were taken during each experiment, being varied in the manner explained above, and the average of the readings was used in plotting the results.

The curve in Fig. 6 gives the theoretical flow through the meter, calculated from the formula already given, the ratio of contraction of the throat area of the Venturi being 1 to 9. The spots show the flow as measured by the tank (on Oct. 11, 1900) and the numbers on the spots refer to the number of the experiments. There were 15 experiments in all, of which three were

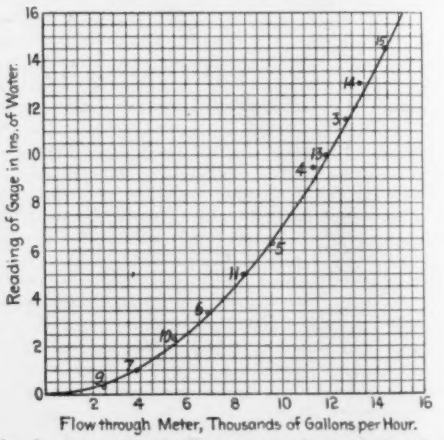

Fig. 6.—Theoretical Flow and Gage Indications, 10-in. Venturi Meter, at Cold Spring, N. Y.
(The curve gives the theoretical discharge; the spots, the measured discharge. Formula for curve:
Flow = 3,813 $\sqrt{\text{reading}}$;
Take actual flow = 3,775 $\sqrt{\text{reading}}$.)

vitiated by trifling errors on the part of the assistants at the tank.

It will be seen that the spots follow the theoretical curve very closely for the most part, and it is only fair to the gage to state that the scales alongside the outer glass columns were not in place and the measurements were taken with an ordinary rule from a line on the board holding the gage. The sensitiveness of the gage was not appreciated at the time and there is no doubt that if a little more facility for accurate reading had been provided the spots would have shown a much closer coincidence with the theoretical curve. The gage is now provided with outer scales, finely divided and accurately located.

The usual coefficient for a Venturi meter is stated to lie between 96% and 100%. Assuming a coefficient of 99% in this case we find that out of the 12 experiments 5 are more than 1% in error, and two spots, 9 and 10, are more than 2% in error, but of these last two 9 is below the limit of the gage. It will readily be seen that below 3,500 gallons per hour the gage must be most carefully read, as a great difference in the flow makes only a small difference in the reading. Spot 7 shows that the gage is entirely reliable down to this limit. At 3,500 gallons per hour the velocity in the pipe is only 12 ft. per minute, which will give some idea of the sensitiveness of the gage.

It is the writer's conviction that, with better measuring facilities on the gage, and a better realization of the accuracy of the instrument than he had when making the experiments here described, it would be easy to make a series of experiments from 3,500 gallons up without any error exceeding 1%.

THE GLASGOW INTERNATIONAL EXHIBITION OF 1901.

By Benjamin Taylor.*

The International Exhibition which is to be held from May to November of the present year at Glasgow, Scotland, will be the most representative and industrially important exhibition ever held in the United Kingdom. Its avowed purpose is to present a full illustration of the products and manufactures of the British Empire, its dependencies, dominions and colonies; and also the largest possible representation from other countries. Large special pavilions are being erected by the Russian and Japanese governments to exhibit the products of these countries on a unique scale. The West Indian Empire will have a section to itself, and practically every country in the world will be represented, including Persia and Morocco, for whom characteristic buildings have been specially erected.

The site of the exhibition is the Kelvingrove Park, where the exhibition of 1888 was held. This exposition resulted in a profit of £58,000 and this was raised by subscription of citizens to £130,000, and the whole was devoted to the construction of a permanent art gallery and museum in the park. This structure is now completed and the new exhibition is intended to commemorate this completion as well as to record industrial progress.

The exhibition is an enterprise under control of the municipality of Glasgow, but its financial success is guaranteed by a fund of £500,000, subscribed by prominent citizens. Any surplus this exhibition may leave will be devoted to the purposes of the gallery and museum, but profit is not aimed at.

The site of the exposition covers an area of 73 acres on the banks of the river Kelvin (a tributary of the Clyde) and under the shadow of the stately classic buildings of the University of Glasgow.

The permanent Art Gallery forms the nucleus of the plan of the exhibition buildings, which are designed by Mr. James Miller, I. A., Glasgow. The style is Spanish Renaissance, and the temporary buildings are designed in harmony with the permanent building. It was the original intention to construct the whole of the temporary buildings of steel, but circumstances have compelled a liberal use of timber. The walls are of fibrous plaster, of American manufacture, faced with pure white stucco, and the roofing (where not of glass) is of corrugated iron painted to resemble red tiling.

The Industrial Hall has a floor space of 26,000 sq. yds. It is 690 ft. in length and 328 ft. in width, and its entire length is traversed by the main avenue, with a three-hinged arch roof of 103 ft. span. The Machinery Hall is separated from the main building and grounds by a busy public thoroughfare, over which a covered bridge has been thrown, forming a continuation of the grand avenue. The plans of the hall have had to be enlarged from the original designs as applications for space multiplied. The building is 500 ft. in length and 320 ft. in width, divided into a central avenue and four side avenues.

*10 Derby Crescent, Kelvinside, N., Glasgow, Scotland.

The Dynamo House stands beyond the main building of the Machinery Hall and is formed by a continuation of the side spans of the main building. It is 100 ft. square, and the boiler house extending along the west side is 20 ft. long and 70 ft. wide. The boiler house has a raised gallery running round on the inside, from which all the different boilers, economizers, etc., can be comfortably inspected.

The Machinery Hall, with the Dynamo House and Boiler House, occupy a space of 20,400 sq. yds. It is in direct railway connection with the Caledonian Railway System. It will be devoted to machinery in motion and, where practicable, actually manufacturing.

The leading architectural feature of the design of the exhibition buildings is the great dome, which rises over the center of the main avenue to a height of 190 ft. with a diameter of 80 ft. It is flanked by four massive towers, each 160 feet high. It was originally intended to use steel for the whole of the structural framework, but owing to the great rise in material and the difficulty in obtaining prompt supplies, it was decided to use timber instead for the structure of the dome and the framing of the main towers.

An exhibition of machinery and machine tools merely representative of the industries of such a great center of shipbuilding, marine and general engineering, boiler making, iron and steel working, sugar making, distilling, spinning, weaving and general manufacturing, as Glasgow is, could not fail in any case to be highly interesting. But this show will be vastly more than that, for it will include examples of the highest mechanical ingenuity and engineering skill of the foremost producers of Europe and America.

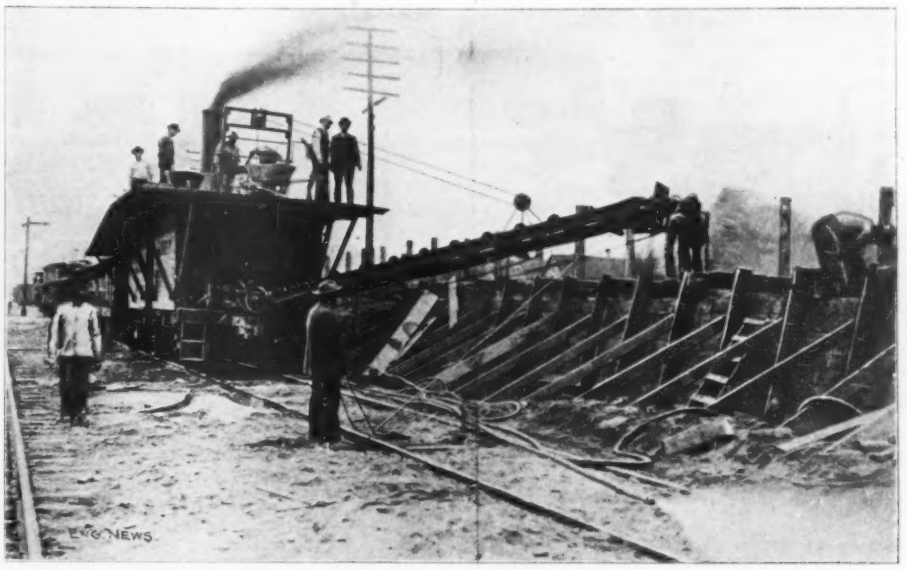

FIG. 1.—CONCRETE TRAIN FOR MAKING AND DEPOSITING CONCRETE FOR RETAINING WALLS; CHICAGO & WESTERN INDIANA R. R.

CONCRETE MIXING AND DEPOSITING MACHINE.

Where concrete is used in large quantities important economies may be attained by the introduction of special means for handling the raw materials and the finished concrete. In the construction of the concrete retaining walls for the track elevation work of the Chicago & Western Indiana R. R., a complete concrete making train has been used, which presents some interesting features. A general view of the train at work is shown in Fig. 1, and similar trains are to be used in the work projected by this and other railways during 1901.

The concrete car is a flat car, fitted with a Drake duplex double-shaft concrete mixer, a concrete conveyor, a 25-HP. vertical engine and boiler, and winding drums for operating the propelling cable. The machinery was enclosed and roofed over, the roof forming a deck or floor from which the materials are dumped into the measuring boxes. The concrete mixer is of the form shown in Fig. 2. It consists of a steel box or trough, 38 ins. wide, the bottom of which is curved to the radius of the mixing blades. In the box are set two shafts fitted with blades and scoops. There are about 60 blades or scoops in all, those on one shaft alternating with those of the other. Of these 75% are straight blades set edgeways; the others are scoops inclined so as to make a bigger cut or scoop than the straight blades. These latter turn the material over, giving it a thorough mixing, while at the same time they force the material along towards the discharge end. The two shafts are geared together, revolving in opposite directions, and one shaft also carried a spur wheel gearing with a pinion on a sprocket wheel shaft which is driven from the engine. The machine will make 400 to 500 cu. yds. of concrete daily, and requires about 25 HP. for its operation. It is 12 ft. 6 ins. long and 5 ft. 6 ins. wide over the oak frame, and 2 ft. 2 ins. high over the hopper. Its weight is about 5,500 lbs. A perforated pipe extending longitudinally over the hopper for about half its length from the discharge end, supplies the water in proper quantity. The materials are well mixed dry before reaching the water pipe.

The train consists of three or four gondola cars of stone and sand, and a box car of cement at the rear end. Wooden runways are placed along the sides of the cars, and are made portable so that they can be removed from the empty cars. Upon these runways men with wheelbarrows convey the material to the deck of the concrete car. Here they are dumped into two measuring boxes, side by side, one being filled while the other is being discharged. This method secures the proper proportions specified for the concrete, and from the boxes the materials drop directly into the hopper of the concrete mixer. When the work was first started, the concrete was discharged by a chute into wheelbarrows and deposited in the usual way. An improvement upon this was effected by equipping the head of the car with a belt conveyor 25 ft. long (or longer if required), mounted on a steel boom. The heel of the boom is mounted on a turntable, so that the conveyor can be swung through an arc of nearly 180°. The boom is also hinged at the heel and supported by guys from a gallows frame on the deck of the car, so that the height of the delivery end can be adjusted as required. This conveyor dispenses entirely with the concrete wheeling gang, and as the material is kept in constant motion it is delivered in better condition than when carried for a distance in wheelbarrow loads.

Another important feature of the equipment is that the entire train is self-propelling. Originally a locomotive was attached to the rear of the train, moving it to and fro along the section of the work in progress, the concrete being deposited in a 6-in. layer. This involved an expense of about $25 per day. To enable this expense to be

eliminated, a double drum winding apparatus was placed on the car, being driven from the same engine which supplies power for the mixer and conveyor. Around the drums were passed eight turns of a ¾-in. wire cable, which passes through a slot in the floor. From the forward drum, the cable extends to an anchor tie 500 ft. in the rear; while from the rear drum it extends to an anchor tie 500 ft. ahead, the working section being nearly 1,000 ft. long. The length depends upon the local requirements in each case. By this arrangement the train is moved steadily forward and backward at the required speed, the

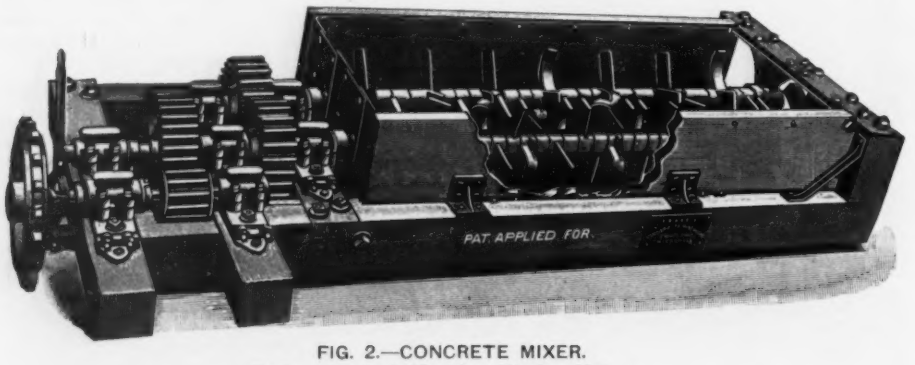

FIG. 2.—CONCRETE MIXER.
Drake Standard Machine Works, Makers.

wheelbarrow gang of about 25 men keeping the mixer supplied with material, and the conveyor delivering a continual stream of concrete into the forms.

A somewhat similar plant has been devised for the concrete foundations of streets and railway tracks, and Fig. 3 shows a machine built for use on street railway contracts, and operated by a 25-HP. electric motor. The mixer, driving gear, and material and concrete conveyors are mounted on a steel frame carried on two axles with road wheels. The lower end of the material conveyor is carried by a pair of small wheels in a frame to which wheeling boards are attached, as shown. The wheelbarrows of sand, stone and cement are wheeled up the plank to the dumping box and dumped sideways upon the conveyor, at the head of which is a vertical chute to the mixer. The concrete delivering conveyor is driven by a sprocket chain from a shaft under the frame, and a sprocket chain also drives one of the axles so as to move the machine as the work progresses. The head of the conveyor is moved laterally to deliver the concrete over the whole width of the work. Similar plants are made having steam engines in place of electric motors, and with or without the conveyors.

While these delivering or depositing machines are comparatively new, the Drake concrete mixer already described is in very extensive use, in both stationary and portable forms, and with one or two shafts according to the capacity. For large plants automatic feeders are used, the material being fed to the mixer by vertical chain and bucket conveyors or by horizontal screw conveyors. The proportions in which the materials are fed can readily be changed by changing the sprocket wheels on the shafts, an index plate attached to the hopper showing what sizes of wheels are to be used. These concrete mixers have been used for the Chicago track elevation at 16th St. (Eng. News, July 14, 1898, and April 13, 1899), and on the Chicago, Rock Island & Pacific Ry., and the Pennsylvania Lines, Chicago; the concrete dock of the Illinois Steel Co. (Eng. News, Dec. 14, 1899); the telephone tunnels of the Illinois Telephone & Telegraph Co. and on various government railway and general contracting works. Nine of the road portable machines, fitted with steam engines and boilers, were purchased by the Dominion Iron & Steel Co., for use at its extensive works at Sydney, Cape Breton, recently described in our columns. The machines are built by the Drake Standard Machine Works, of 208 Jackson Boulevard, Chicago, and we are indebted to the makers for photographs and other information. Three patents have already been allowed to Mr. Drake, and others are pending.

IMPORTANCE OF ECONOMIZING TONNAGE FACILITIES BY COMPACT STOWAGE OF CARGOES.

By Henry P. Jones, M. E.*

A very general interest has been shown in the Ship Subsidy Bill, now pending in Congress, and as attention is therefore being directed to questions relating to ocean transportation, certain facts which have been developed by the writer are believed to be worthy of consideration.

As frequent reference will be made to various terms and units of comparison, a brief explanation of them may lead to a more accurate comprehension of certain statements.

A ship's register is its evidence of national character and officially sets forth certain facts, among which is a statement of the vessel's capacity. This capacity is ascertained by methods which are fully prescribed by law, and as the measurement laws of the principal maritime nations are similar, the results stated in foreign registers are, with certain minor limitations, accepted by these countries as a mark of international courtesy.

Assuming therefore that the regulations of the United States fairly represent the basis upon which the capacity of all vessels clearing from United States ports is computed, attention will be confined to a statement of the general requirements of these regulations. For the purpose of obtaining the internal capacity of a vessel, certain official measurements are taken, known as tonnage measurements, and the results are expressed in tons of 100 cu. ft. each. As the true intent is to ascertain the amount of space capable of producing a valuable return from the transportation of cargo, stores or passengers, it is evident that deductions must be made for space not thus available. The total internal capacity of the vessel is known as its gross tonnage; from this gross tonnage certain specified deductions are made and the result represents the space remaining for cargo, stores or passengers, and is known as the net or registered tonnage of the vessel.

In vessels having three or more decks, the second deck from below is termed the tonnage deck, in all other vessels the upper deck is known as the tonnage deck, and the gross tonnage comprises the space under tonnage deck, the space between decks above tonnage deck and spaces on the upper deck which are permanently enclosed or sheltered from sea and weather and used for cargo, stores or passengers.

In determining the net tonnage of a vessel, the tonnage capacities of the following spaces are the principal deductions made from the gross tonnage. Spaces certified to be for the accommodation of master, crew, instruments, boatswain's stores, auxiliary machinery, etc. In vessels propelled by screws, in which the tonnage space actually occupied by, or necessary for the proper working of, boilers and machinery exceeds 13% and is less than 20% of the gross tonnage, a deduction of 32% of the gross tonnage is made. In case the actual tonnage space so used amounts to 13% or under, a deduction amounting to 1¾ of the actual space is made. If the space so used actually amounts to or exceeds 20% a deduction is made of 3[illegible] of the gross tonnage, or of 1¾ of the space actually us[illegible] at the option of the shipowner.

It seems reasonable to assume that in utilizing tonna[illegible] the maximum commercial benefit would result from condition in which the greatest value is carried per [illegible] ton. Such a condition evidently depends upon the va[illegible] of the commodity and upon its bulk, the former fl[illegible]tuating according to the demand and the cost of pr[illegible]duction, the latter remaining practically constant.

A considerable part of the gross weight of vessel a[illegible] cargo is above the water line, and as the problem [illegible] ocean transportation, aside from constructive and mecha[illegible]ical features, is based upon the fact that the gross weig[illegible] of vessel and cargo will be equal to the weight of t[illegible] water displaced, it is evident that the average density [illegible] the cargo must be less than that of water (64.3 lbs. p[illegible] cu. ft.), and that compact stowage therefore has its li[illegible]itations so far as average density of cargo is concerne[illegible] The smaller the proportion of total displacement requir[illegible] to equalize the gross weight of the vessel itself, the gre[illegible]er will be the average density of cargo allowable, an[illegible] the limit for different vessels will, in general, vary a[illegible]cording to construction.

It is evident that commodities exported differ greatly i[illegible] density, and, if the suggestion of an ideal condition b[illegible] permitted, it may be stated that the maximum efficiency of the total tonnage would be attained if exports of varying densities be so proportioned in each cargo that the resulting average density would coincide with the limit allowable for the vessel.

It is not the writer's purpose to discuss improved methods by which the density of certain bulky exports may be increased and savings in freight effected; but rather to make clearer, if possible, the commercial significance of practically increasing the capacity of present tonnage facilities by decreasing the bulk of commodities when possible.

From the point of view of the shipowner, the proposition of more compact stowage may not, at first sight, seem attractive; and statements have been made to the effect that such an improvement would not be to their interest, as fewer vessels would then be required. The annual value of exports by sea from the United States, however, has increased more than 50% in the past ten years, and during the same period there has been an increase in the net tonnage clearing annually in foreign trade amounting to more than 82%. Even with this relatively great increase in facilities, tonnage famines have been frequent and traffic in certain exports has undoubtedly been retarded by lack of accommodations at other than prohibitive rates. There is every indication that exports will continue to increase from year to year and the above percentages seem to warrant the conclusion that, even with reasonable allowance for prospective increase in tonnage, a ready demand will exist for cargo space at rates profitable to the shipowner.

While ocean freight rates are, in general, based upon space occupied, rather than upon the intrinsic value of the goods carried, yet it is safe to assume that economy in stowage which would make possible the transportation of cargoes of greater average value, would tend to increase rather than decrease the shipowner's profit. It may be added that any readjustment of present rates, due to increase in density, would probably not be in direct proportion to the true economy effected in stowage, therefore the shipowner would share with the producer and the consumer in the apportionment of the savings.

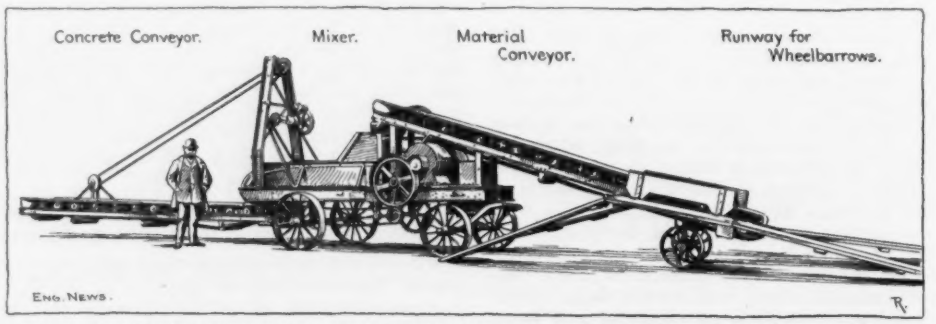

FIG. 3.—CONCRETE MIXING AND DISTRIBUTING PLANT FOR STREET RAILWAY WORK.
Drake Standard Machine Works, Makers.

As statistical information regarding the annual export of cotton has been accumulated in detail, and as reliance may be placed upon that export as a fairly constant source of income to the United States, it affords an excellent illustration of lack of economy in the transportation of a bulky product. The fact that during the past 20 years the annual value of the cotton export has averaged 25% of the total annual value of all exports, by sea or land, is an indication of its commercial importance. The localizing of traffic at certain ports is a notable feature of the export trade, and this is particularly true of the annual export of cotton. During the year ending Aug. 31, 1900, more than 65% of the total weight of cotton exported was shipped from New Orleans, Galveston and Savannah, and during a period of ten years ending June

*183 Essex St., Boston, Mass.

30, 1899, the average importance of the export of cotton in the total annual export trade of each of these ports was 75.31% of the total value for New Orleans, 86.48% for Galveston and 77.73% for Savannah.

The position which cotton occupies in the total export trade of each of these three ports fluctuates from year to year, but during the period of ten years ending June 30, 1899, its relative importance had very generally decreased, due largely to an increase in other exports. While a certain proportion of the decrease in value of exports per net ton may be attributed to this tendency toward diversified traffic, the greater part of the decrease is due to the decline in the value of cotton. Comparing the year 1899 with 1890, the value per pound of the cotton export declined 46.17% at New Orleans, accompanied by a decrease of 42.28% in value of exports per net ton; 43.28% at Galveston, accompanied by a decrease of 41.22% in value of exports per net ton; 49.76% at Savannah, accompanied by a decrease of 43.20% in value of exports per net ton.

The comparatively high value of cotton cargoes, even with present lack of economy in stowage, is gratifying in so far as the commercial benefit derived from the tonnage employed is concerned, but in view of the marked tendency toward a decline in value per net ton at cotton ports, the question of economical stowage is of increasing importance, and it is immaterial whether this decline is due to decrease in price of cotton or to other causes.

The charges for ocean transportation may, to an extent, be influenced by fluctuations in cost of labor, and in market prices of coal and other materials consumed or employed in affording such transportation; but the controlling factor is the demand for cargo space. The great increase in exports and consequent demand for tonnage has already been noted, and it is not probable that the decline in value per net ton at cotton ports has been accompanied by any corresponding reduction in cost of transportation. From an economic point of view, a condition which requires a fixed expenditure for the transportation of a commodity which has been subject to a considerable decrease in value, needs little comment, even though this freight expenditure represents a relatively small percentage of the intrinsic value of the commodity, as is true of cotton.

The present year has shown a considerable increase in the price of cotton, and it is possible that such excellent market values will continue, but until developments have proved these values to be the rule rather than the exception, the average tendency during the period herein reviewed may be accepted as fairly representing general conditions.

As regards the cost of transportation of bulky exports, the tendency will be toward an increase rather than a decrease, unless tonnage facilities increase in a considerably greater ratio than the exports. If greater economy in stowage be secured, a reduction in freight charges may reasonably be demanded, and the importance of such a reduction obviously increases as the value of a commodity decreases.

As an illustration of the possibility of virtually increasing the merchant marine by compact stowage, it may be stated that if the total cotton export of 1899 had been shipped at a density which can now be economically obtained by modern methods, transportation facilities equivalent to approximately one-third of the total net tonnage clearing in foreign trade from New Orleans, Galveston and Savannah during that year, would have become available for an extension of traffic, and at the average value per net ton prevailing at New York in 1899, would have afforded transportation for exports amounting to nearly fifty-four millions of dollars.

While much attention has been effectively devoted to problems connected with the utilization of waste products and to other similar economies, the character of the packages in which many of our exports are shipped seems to have attracted little attention other than adverse criticism from foreign consignees. At certain ports there is a demand for a small amount of "light freight," to offset the greater density of other portions of the cargo; but aside from such comparatively unimportant conditions, the value of a dense package, the cost of securing which shall not exceed the benefits derived, seems evident, and in many cases an improvement may be effected at even less cost than that of present inefficient methods.

The advantages of increased density are not confined to questions of stowage, but include insurance and other savings of no inconsiderable amount. It is not proposed, however, to discuss these features at the present time, and it is believed that the facts relating to stowage here presented, though pertaining largely to the cotton export, indicate a present loss of economy extending to many commodities.

According to the most reliable statistics, the merchant marine of the world amounted in 1900 to a total of 20,512,877 net tons, including sailing vessels of over 50 tons and steam vessels of over 100 tons. Of this amount 59.31% represented steam vessels. These figures show the tonnage facilities available for the ocean traffic of the world, and the total net tonnage clearing from the United States in foreign trade during 1900 exceeded in amount the total of all these vessels by 37.08%.

Referring to recent statements which have appeared in connection with the proposed increase of the merchant marine, to the effect that only by decreasing freight rates can American vessels hope to compete with foreign vessels in the carrying trade of this country, which they controlled to the extent of 93.10% in 1899, the above facts are presented for consideration not only as a possible means of reducing freight rates, but also as a means of increasing tonnage facilities.

THE NEW YORK STATE CANALS IMPROVEMENTS REPORT.

As many of our readers know, one of the principal duties of State Engineer Edward A. Bond, of New York, during the past twelve months has been the making of a survey, plans and estimates for a barge canal across the State, for which work the State Legislature appropriated $200,000 on April 12, 1900. On Feb. 20, Mr. Bond submitted to Governor Odell the report of his work, and abstracts of this report have been published in the daily papers, from which we select the following statements of general interest:

The estimates are: For building an Erie barge canal capable of accommodating boats 150 ft. long, 25 ft. beam and 10 ft. draft, $49,000,000; for deepening the Oswego Canal to 9 ft., $859,026; for deepening the Champlain Canal to 6 ft., $5,472,000; total cost of canal improvement, $55,331,026.

The estimate of $49,000,000 is for canal of size suitable for barges of 10 ft. draft, 25 ft. width and 150 ft. length. The canal, as planned and estimated for by these routes, is first-class in every respect, with locks of the most modern type, capable of passing two boats at once, with recent improvements and methods for filling and emptying the locks, with power generated to pull the boats into and out of the locks, operate the gates and valves and furnish electric light. In the river and lake channels the minimum width is 200 ft. Both the bottom and sides of the canal are to be thoroughly puddled. Guard locks are provided wherever required, and in the canal sections guard gates are provided at distances apart not exceeding ten miles, so that any section can be shut off for repairs. A full complement of first-class new bridges is provided wherever required.

In the navigation of the proposed canals, only steam, electric or other mechanical motors have been considered, consequently the towing path will be a thing of the past. The estimate covers the marking of the channel of the canalized rivers by spar buoys anchored to the bottom of the river and easily distinguished. Each lock is to be equipped with four arc lights on the lock proper and one on each approach. Besides these, incandescent lighting will be furnished by the lock houses.

A large expenditure for water supply, not contemplated by the canal committee, has also been provided for in the estimate. The question of water supply is a very important one, and in making the plans provision is made for safely and surely at all times in the dryest season passing 10,000,000 tons of freight a year and at the same time fully conserving all existing water power and protecting corporate and municipal interests.

Steel lift locks at Cohoes and Lockport will not be adopted, but new masonry locks will be constructed. Much higher lifts will be made with the new locks than anything heretofore attempted on the present Erie Canal. The problem of a high gate, more than anything else, kept former engineers from risking higher lifts, but this difficulty has been so thoroughly overcome by the solidly built gate in use on the Canadian canals that at the present time it is not thought impracticable to build a lock with a 40 or 50-ft. lift.

The route favored is from Waterford to Cohoes Falls; thence through the Mohawk River to Rexford Flats and Little Falls, crossing the New York Central road four miles east of Genesee St., Utica; running north of Utica and recrossing the New York Central about two miles west of Oriskany, passing south of Rome to Fort Bull; thence down Wood Creek to Oneida Lake and going 19.58 miles in deep water through the lake; thence following the Oneida River, with the exception of two large bends west of Brewerton, to Three River Point; thence up the Seneca River to the outlet of Onondaga Lake; continuing west from the outlet along the Seneca River through Baldwinsville to and through the state ditch at Jack's Reefs; thence westerly following the river to a point west of Savannah and paralleling the New York Central road and to the northerly of it to a junction with the present Erie Canal, 1.8 miles east of Clyde, with a change of about 4,800 ft. near Lyons; thence along the present Erie Canal, with the exception of about one-half mile at Newark, to Macedon; thence following the present line of the Erie Canal to a point one mile west of Pittsford; thence across the country south of Rochester until it reaches the Genesee River near South Park. Here it crosses in a pool formed by a dam in the Genesee River, and, keeping to the west of the outskirts of Rochester, joins the present Erie Canal again about one mile east of South Greece.

To provide Rochester with a harbor on this route the river would have to be canalized for nearly a mile; or, in other words, to the mouth of the present feeder. This feeder enlarged to proper dimensions would then furnish a harbor for Rochester. The entire distance to be traveled on this additional piece of canal is about 2¾ miles, from there following the line of the present canal to a point near Medina, where there is a change in alinement of some 3,500 ft., crossing the Oak Orchard Creek, about 1,500 ft. to the north of the present location; from there to Lockport, following substantially the present location, and so on to Tonawanda, with the exception of one or two changes in Tonawanda Creek from Tonawanda to the Niagara River and continuing on the river to the sloop lock at Black Harbor and thence through said harbor and the Erie Canal to the city of Buffalo.

The State Engineer gives two other routes, one of them taking in the Oswego River and Lake Ontario instead of the Seneca River, as above, and another a modification of the present Erie Canal. Both of these are declared not only more expensive, but if constructed would cost the state a great deal more for maintenance and involve open lake navigation from Oswego to the mouth of the Niagara River, and would require a stronger style of barge than for the interior routes and would be more subject to detention from storms.

WHITE LEAD is being produced by the action of the electric arc, using a method invented by Mr. E. Bailey, of York, England. Gases are blown upon the lead while it is in a molten state in the presence of the arc. The fumes produced are blown over into chambers having cloth covers or roofs. The powdered white lead falls down and the unconsumed gases pass through the cloth to be used again.

THE TOPOGRAPHICAL SURVEY OF MICHIGAN, in conjunction with the U. S. Geological Survey, is being urged before the Senate and Legislature of that state by a committee of the Michigan Engineering Society. The reasons given are: That there is no map of the state worthy of that name; much money is wasted each year in re-surveys owing to the lack of a reliable map recording past surveys, and that land drainage, irrigation, sewerage, water-power development, the location of railways, etc., all imperatively demand a contour, topographical map. Unfortunately, the majority of the states can urge the same reasons, and as yet very few are completely mapped according to modern methods.

THE SICILIAN SULPHUR DEPOSITS, says M. Fritz Krull in the "Zeitschrift des Oesterr. Ingenieur, etc.," of Dec. 14, 1900, are practically confined to a basin extending about 56 miles north and south, and 99 to 434 miles east and west, and the principal centers of mining are: Girgenti, Licata, Caltanisetta, Racalmuto, Zalfari, etc. The mines belong to the landowners, and small undertakings predominate to such an extent that modern methods of rapid extraction are impracticable. But the proportion of individual mine operators is rapidly growing less, and their place is being taken by companies having sufficient capital to introduce modern machinery. The product of the existing 500 workings is about 400,000 tons annually, and it is estimated that about 65,000,000 tons of sulphur have been extracted from the Sicilian beds. The percentage of sulphur in the mineral is 30 to 40% as a maximum, with a mean of 20 to 25%. While some of the mills and furnaces are of modern design, the transport of the sulphur to shipping ports is usually very primitive—on the backs of mules or in two-wheeled wagons; very few railways of any type are employed in this industry. The total export of sulphur from Sicily, in 1898, was 447,000 tons, valued at 92 francs, or $18.40 per ton. In 1891, 347,000 tons were exported, then valued at $22.60 per ton; since 1891 the quantity exported has gradually increased, and the price was as low as $11.00 per ton in 1895.

THE MIDDLESEX CANAL, a once famous waterway connecting Boston and Lowell, has practically disappeared, the bed of the canal having been almost obliterated in the building operations and land improvements of the last ten years especially. This canal was chartered in June, 1793, and Samuel Thompson, of Woburn, afterwards Count Rumford, first ran the levels, but he was succeeded as levelman by Mr. Weston, of Philadelphia, acting under Col. Loammi Baldwin as Superintendent. The Merrimac River was utilized from a point two miles above the present city of Lowell, and the total length of the canal, to the Charlestown mill pond, was 27¼ miles. The canal was only 30 ft. wide and 4 ft. deep; and on its line were 7 aqueducts, 20 locks and 50 bridges. This canal was opened to public use in 1803; and was closed in 1846 following the building of the Boston & Lowell R. R. parallel to the canal. Its charter was forfeited in 1859. The total cost of the Middlesex Canal was $613,000, with labor at $10 per month plus board. The Middlesex Canal, though one of the oldest in the United States, is omitted from several lists of American canals consulted; and the only account found of any value is included in the inaugural address of Mr. Desmond Fitzgerald, as President of the American Society of Civil Engineers, and contained in Vol. XLI., 1899, of the Transactions of that Society and in Engineering News of June 28, 1899.

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The plan of water purification for Washington, D. C., recommended in the expert's report, published elsewhere in this issue, is directly in line with the suggestion made in our issue of May 17, 1900. In an editorial discussion of the report in which Colonel Miller advised mechanical filtration, we said:

> As to whether mechanical filtration along the lines recommended is the best means of improving the quality of the Washington water, the report is hardly convincing. There is little doubt but that the proposed plan, with some modifications, will give a very satisfactory water, but it is by no means certain, from the evidence presented, that equally good results might not be obtained by a combination of storage, subsidence and slow sand filtration, with coagulation at certain periods of very bad water.

This suggestion was based largely on the report in question, particularly on the direct recommendation to the same effect made by Mr. Robert S. Weston, in his supplementary report detailing and interpreting the chemical and bacterial results obtained in the Washington experiments. Colonel Miller passed by Mr. Weston's recommendation, on the grounds that the proposition had little in the way of actual experience to support it, and that the appropriation was too limited to investigate the possible merits of coagulation as a supplement to subsidence and slow sand filtration. The report just made by Messrs. Hering, Fuller and Hazen assumes that the knowledge gained in the experiments at Louisville, Pittsburg and Cincinnati, together with that obtained in the Washington experiments, and from the 23 years' turbidity records at Washington, is quite sufficient to warrant the choice of slow sand filtration for the national capital. Some one or more of these three men have been connected with most of the notable water purification experiments conducted, and works built in this country in recent years, besides having personally inspected many of the water purification plants of Europe. It would therefore seem as though their report might be accepted as final, and action taken upon it, in which event the water supply of Washington will soon cease to be a national disgrace.

In a contribution printed elsewhere in this issue, an engineer points out some of the losses in transportation due to defective systems of packing, and makes the statement that if the cotton exports of the United States in 1899 had been baled with the density now possible with modern methods, the shipping space thus set free would have made room for exports to the value of nearly $54,000,000. The comparison might be further extended to include the movement of cotton by rail. More compact baling of the cotton crop would enable it to be transported from the gin to the mill or the shipping port in a smaller number of cars. Of course, such economies in transportation cannot be directly effected by either railways or steamship companies. They must carry the goods in whatever shape they come. They can, however, foster such economical methods of packing by giving the shipper a part of the economies resulting from such packing, in the form of more favorable rates for the denser package; and in the long run it will certainly result to their advantage to do this.

THE UNITED STATES EXPORT TRADE AND TARIFF WALLS.

The United States is now the greatest exporting nation in the world. During the calendar year 1900, the value of United States goods exported to foreign countries reached the enormous sum of $1,453,013,659. The exports of Great Britain in 1900 amounted to $1,418,348,000, while Germany's were valued at $1,050,611,000. It is true that the greater part of American exports is still composed of raw materials, cotton and grain being the largest single items; but the exports of manufactured goods from the United States have also been increasing by leaps and bounds, and it is to this, in fact, that the great growth of the nation's exports during the past decade is due. In 1900, for example, we sent abroad manufactures of iron and steel alone to the value of $129,633,000.

The time was—and not very long ago—when the situation of the United States was entirely different. Our exports were almost wholly of raw materials, and American manufacturers, with few exceptions, made no attempt to send their goods abroad to be sold in competition with those of foreign makers. Instead, they were in dread lest the foreign manufacturer should come in and contest their supremacy in the home market. To prevent that result, a tariff wall was built around the United States, so high and so broad that the American producer could snap his fingers at his foreign rival.

That wall still stands. To the outward eye it seems as stable as the day it was erected; but the keen observer is aware that its foundation is gradually being undermined. Year by year it grows more and more unstable; and occasionally, as happened only a few days ago, a sudden storm lays bare its weakness, and sets men to asking what the top-heavy and dangerous structure is retained for anyhow.

Years ago, when the question of protection was a live political issue, it used to be said—and said with truth—that what the business world desired above all else was freedom from tariff-tinkering. "We can do business under a high tariff or under a low tariff," said the manufacturers, "but no man, be he maker, or buyer, or seller, can do business with safety while the tariff is a bone of contention, and is likely to be changed at any time."

When that eminently sound proposition was laid down, nobody thought of anything else than the United States tariff. It was protection against foreign manufactured goods, about which American owners of mills and factories were worrying. Now, however, a large number of American manufacturers have suddenly awakened to the fact that they can control the home market, no matter what the United States tariff may be, and what they are now concerned about is the tariff rate of certain European countries.

As those of our readers who follow the daily papers are aware, Russia, on Feb. 15, issued an order increasing by 30% the tariff rates on the principal imports from the United States, the order to take effect on March 1. The United States sold to Russia last year about $10,000,000 worth of manufactured goods, and a large number of American firms have within the past two years invested large amounts in the establishment of facilities to build up and increase their Russian trade. The Russian market, with its great undeveloped resources, its awakening demand for machinery, tools, metals and all sorts of appliances of civilization, is well understood to have enormous possibilities of development. Now comes this order of the Russian Government, and at a single stroke knocks a million dollars or so out of the pockets of American manufacturers, in the shape of increased duties on goods which they are under contract to deliver. In addition, it places the American manufacturer under a handicap that makes him well-nigh helpless to compete with Russia's next-door neighbor, Germany, in the sale of goods.

To explain the reason for the increase of the Russian duties, we must go back a little. When the United States tariffs of 1894 and 1897 were framed, a clause was inserted to the effect that on any sugar imported from a country which paid a bounty on sugar production or export, an additional duty must be paid equal to the amount of the bounty. To the ordinary man it may seem that if a foreign government chooses to pay part of the cost of producing sugar or any other commodity which is to be sold to American consumers, it is practically so much put into their pockets. Our tariff framers, in their wisdom, however, were not willing the American sugar consumer should reap any such benefit. It was the American sugar manufacturer for whose interests they were looking out; and viewed in this light, the "countervailing duty," as it is termed, on bounty-aided sugar, can be understood.

Among the countries from which the United States imports sugar is Russia; but the imports are trivial in amount, only averaging about $75,000 per annum. Now, Russia does not pay a government bounty on either sugar production or sugar exportation; but she does assess certain internal revenue taxes in such a way that Russian sugar producers can export their surplus production, and the Russian sugar consumers have to pay indirectly part of the cost. Does this constitute a government bounty, such as the Dingley tariff law requires to be offset by a countervailing duty? In 1898, the U. S. Treasury Department thought it did, and ordered the countervailing duty to be collected. On April 24, 1900, it concluded it did not, and orders were issued suspending the collection. Two weeks ago it again reversed its decision, and reimposed the countervailing duty, and the Russian authorities promptly retaliated with the increased duties on United States goods imported into Russia, which we have noted above.

It is not necessary to explain here all the intricacies of the Russian sugar question. It is worth while, however, to note a few facts. The first of these is that the Russian sugar bounty—if bounty it can be called—is paid, not by the government, but by the consumers. The United States explains to Russia that even though the Russian sugar consumers pay it, it is a bounty just the same, and Russia replies with caustic politeness that from that point of view a large part of the export trade of the United States is bounty-aided, since it is well known that the American manufacturer, protected by the tariff wall, charges the American buyer a much higher price than the foreign buyer. This is especially the case on goods whose production is in the hands of a trust. It is the definite policy of certain trusts, in order to pay dividends on their watered capital, to extract from the home consumer as high prices as he will stand and dump the surplus on foreign markets for whatever it will bring.

Another fact, not heretofore made public, is that the reason why the countervailing duties on Russian sugar were removed in April last, was that a secret reciprocity treaty was pending between Russia and the United States, and that the remission of the countervailing duty was asked for

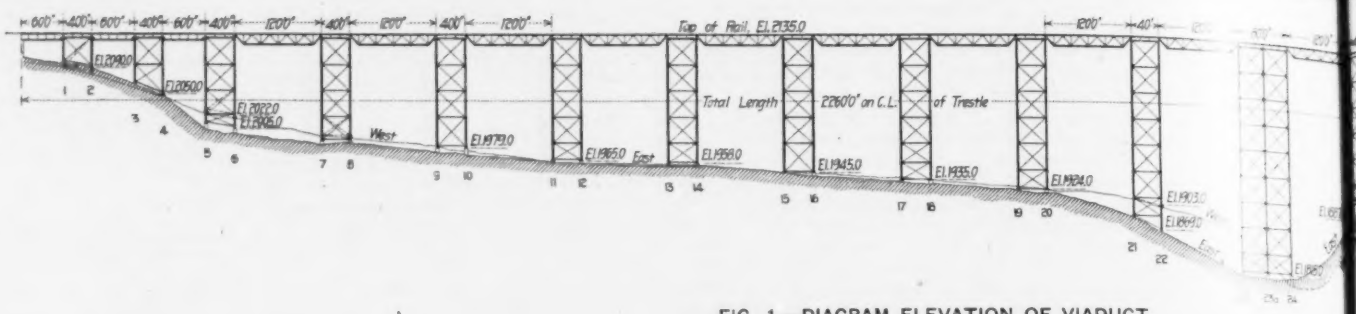


FIG. 1.—DIAGRAM ELEVATION OF VIADUCT.

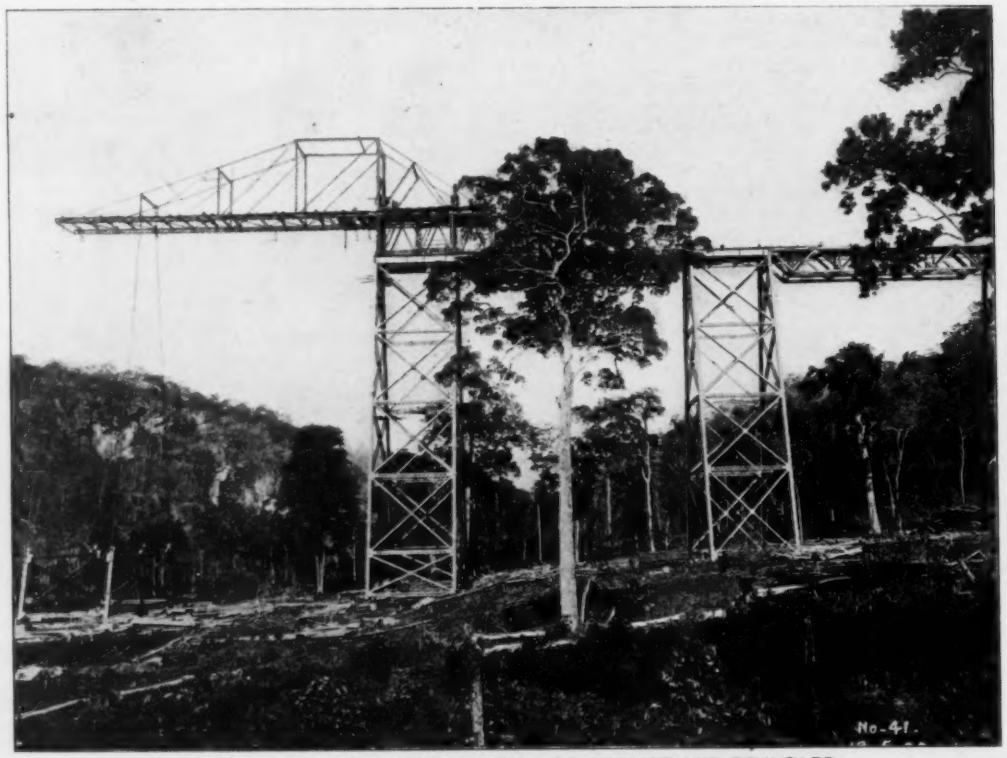


FIG. 3.—VIEW SHOWING PORTION OF VIADUCT AND TRAVELER IN SIDE ELEVATION.

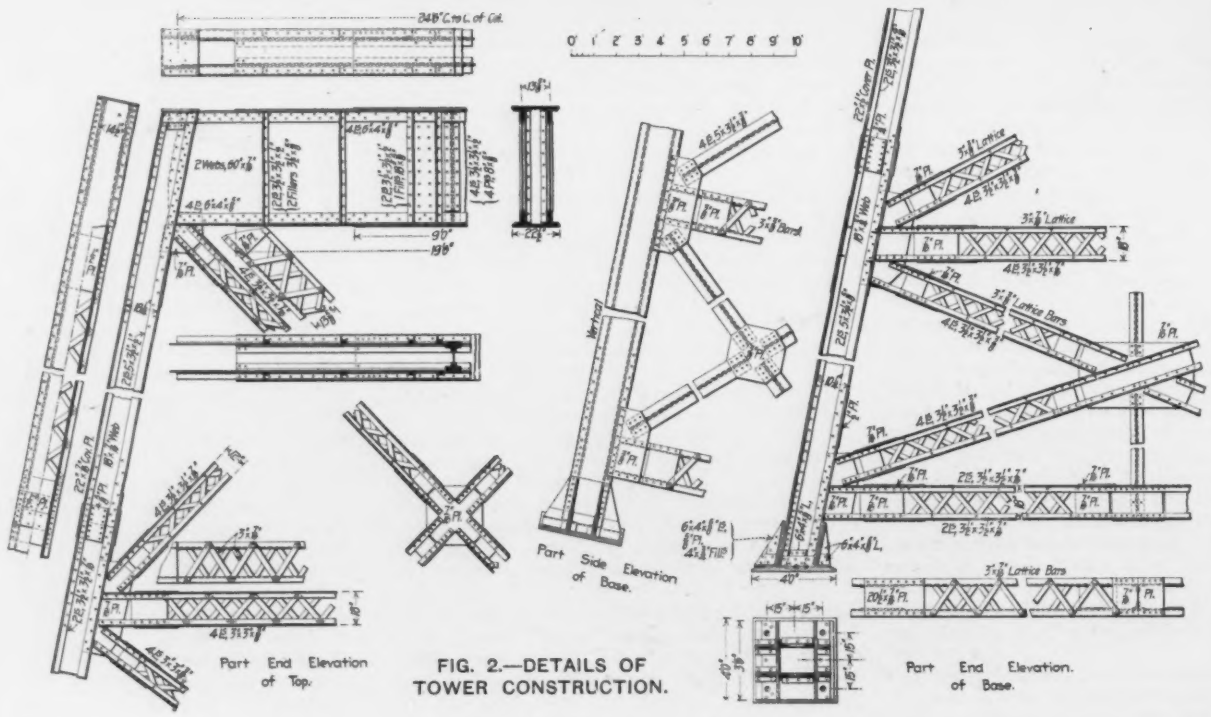


FIG. 2.—DETAILS OF TOWER CONSTRUCTION.

FIG. 4.—V[illegible] SHOW[illegible] A[illegible] DEEPE[illegible]

THE [illegible]GOKT[illegible]
BU[illegible]MAH[illegible]
BU[illegible]

Sir Arthu[illegible] Renc[illegible]

Consulting En[illegible]neers

Pennsylva[illegible]a St[illegible]
B[illegible]

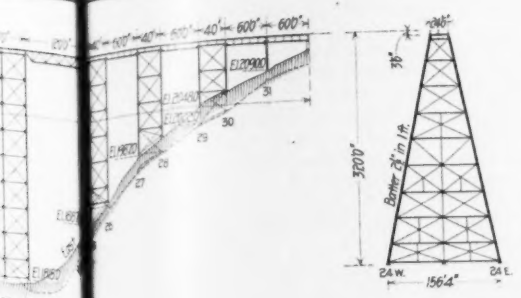


FIG. 4.—VIEW SHOWING THREE-BENT TOWER AT DEEPEST PART OF GORGE.

THE GOKTEIK VIADUCT
BURMAH RAILWAYS,
BURMAH.

Sir Arthur Rendell & Co.,
London, England.
Consulting Engineers, Burmah Railways, Ltd.

Pennsylvania Steel Co., Steelton, Pa.,
Builders.

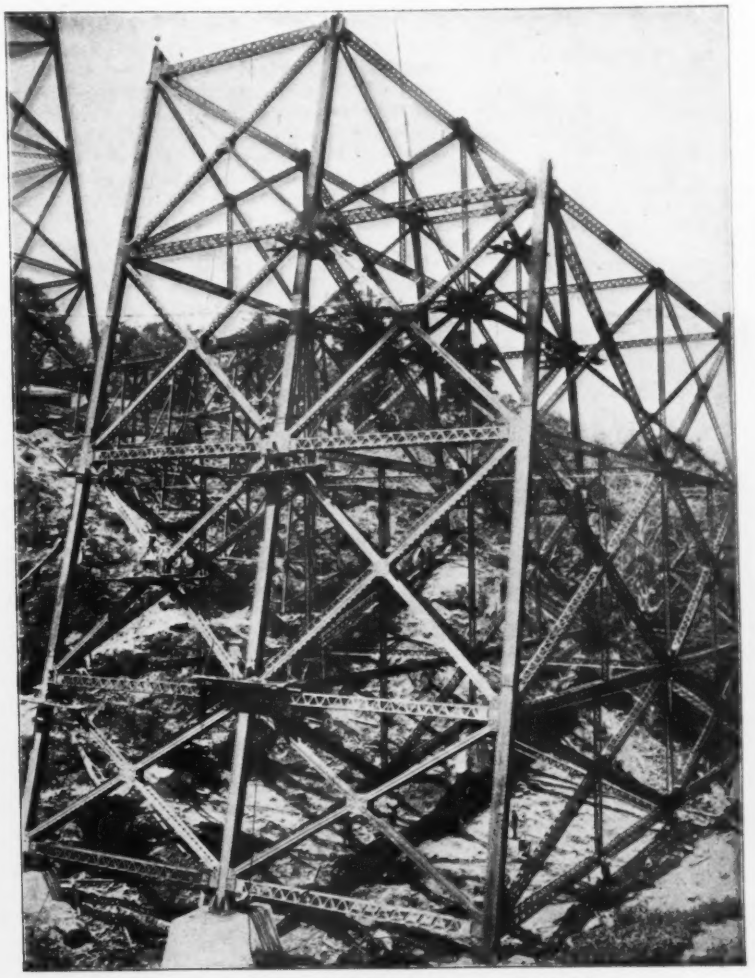


FIG. 6.—ENLARGED VIEW OF THREE-BENT TOWER FRAMING.

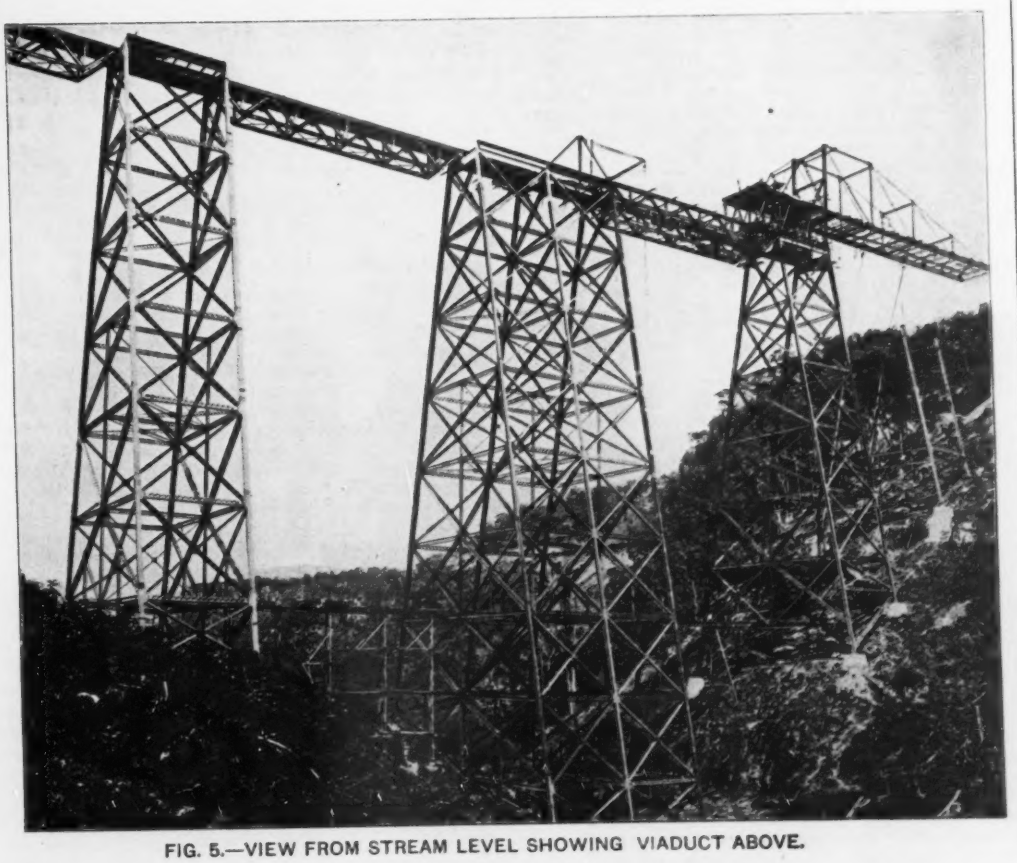


FIG. 5.—VIEW FROM STREAM LEVEL SHOWING VIADUCT ABOVE.

and granted pending the ratification of the treaty (which provided for the removal of the duty as a permanent condition).

The framers of the tariff wall of 1897 appear to have had suspicions that their structure had too great height for its base. They, therefore, tacked on a clause empowering the President to negotiate reciprocity treaties with various countries in which he should agree to knock something off our wall here and there on condition that the other parties should knock off more or less from their walls erected against our goods. Treaties and agreements of this sort have been drafted with numerous countries, and several of them have gone into effect. A number of others require the ratification of the Senate to make them effective, and this ratification has been long delayed. Hope has been, in fact, abandoned that such ratification can be secured before the expiration of the present Congress. This means, we understand, that these pending treaties will expire by limitation and new agreements must be effected with the contracting parties, provided that they are not by that time tired of granting concessions and making bargains only to have them ignored or turned down.

The fact is—and it may as well be plainly stated—that while the reciprocity treaty business is a fine thing in theory, it doesn't work well in practice in the United States. It seems at first sight an excellent plan—setting the statesmen of two countries to bargain with each other on behalf of their respective nations to arrange for such reciprocal interchange of trade as will be mutually beneficial. But in practice the diplomats on either side, even though we grant them the best intentions, are not and cannot be familiar with all the branches of trade, and their respective values and importance. Thus the reciprocity treaty, like the tariff itself, is really originated by those engaged in the trade which is to be affected by it. The merchant or the manufacturer or the trust, does not sit still and wait for the government in its wisdom to arrange a reciprocity treaty under which he or it can do business. Well-paid agents are sent to Washington, to Rio Janeiro, to St. Petersburg, or anywhere else that influence will tell, and these agents make plain to the statesmen what their principals want. Naturally what suits one interest may be exactly what does not suit another. So these rival interests pull and haul away; the statesman—if he be a statesman—endeavors to harmonize differences and make the best bargain he can with the representatives of the other nation. If he is something other than a statesman he first makes the best bargain he can with the rival interests. Then the treaty—good or bad—runs the gauntlet of the Senate, and the same battle of conflicting interests and conflicting influences may be fought over again there. Why should it be expected under these conditions—inherent in the system, not in the men or the party—that foreign representatives should take the trouble to negotiate favorable reciprocity treaties with the United States? Why should we expect anything but that the trust with the deepest treasury and the most influence should win the game?

But the failure of the United States to cultivate friendly trade relations with foreign countries—the lapsing of the pending reciprocity treaties and such tariff reprisals as the imposition of the countervailing duty on Russian sugar, are matters closely affecting American prosperity. The artificial stimulus afforded by protection has built up in the United States an enormous productive capacity, much beyond the ability of this country alone to absorb. Our foreign markets are more and more necessary to keep our mills and factories busy and prevent stagnation and idleness among employees, loss of wages and purchasing power and consequent financial disaster.

The manufacturers of the United States want the world's market. They are big enough and strong enough and rich enough to compete with the manufacturers of any other nation, with a fair field and no favors. The tariff wall about the United States is no longer needed to protect the infants inside. These youngsters have outgrown swaddling clothes and bands, kilts and knickerbockers, and some of them have developed such giant stature as even to cause genuine alarm to the mother which nursed them.

Two parties alone contend for the retention of this high tariff wall. The one is composed of politicians and their following of voters to whom protection has become a shibboleth, and who have no knowledge of the fact that the revolution which the past ten years has wrought in the industrial and financial system of the United States demands a revolution in the nation's position toward international trade. The other of these parties is composed of the trusts, who find the tariff wall a convenient aid in maintaining excessive prices to the home consumer, while they dump their surplus on foreign markets at prices fixed by international competition.

Against these two parties we have ranged, first, the great body of consumers, to whom the exactions of the trusts have grown more obnoxious every year, and who only wait the opportunity when the issue shall be plainly presented to order the complete overthrow of the tariff wall. Occupying a scarcely less radical position is a great body of independent manufacturers, who find themselves hampered at every turn in endeavoring to built up their foreign trade by the tariffs of foreign countries, which are justified in each instance by our own high duties. In addition to this, they, too, find themselves obliged to contribute toward dividends on the swollen capitalization of the trusts through the exorbitant prices which they must pay for much of their raw material.

Time was when the tariff was a political question, on which the two great parties waged fierce battles; but it is no longer a question on which either political party is united. Last week in the House, Mr. Babcock, of Wisconsin, a prominent Republican member of the Ways and Means Committee, and Chairman of the Republican National Congressional Committee, introduced a bill removing all duties from most of the metal items in the Dingley tariff. It is an open secret that whenever the issue as to sugar duties is squarely presented to Congress, not only countervailing duties, but all other duties on sugar will be swept aside. In fact, the public demand for the removal of duties on all products in which trusts control the prices is growing too strong to be long resisted.

It is true that the present Congress expires within a few days; and if the new Congress is called together in an extra session, it will probably venture on little legislation outside of the pressing questions relating to Cuba and the Philippines. Tariff revision will, therefore, be postponed in all likelihood to the session beginning next December; but the forces which are pressing it forward seem certain to make it a prominent issue then.

LETTERS TO THE EDITOR.

Stadia Surveys for Railway Work.

Sir: In connection with the article "Stadia Surveys for Railway Location," by H. P. Boardman, in your issue of Feb. 21, I wish to call attention to the usefulness of stadia methods, as Mr. Boardman describes them, in making surveys for changes of a mile or two for betterments in grade or alinement in existing roads, and also to its use for quick determination of the drainage area and elevations of small streams in designing the size of openings for culverts on new work or in replacing old wooden trestles with permanent structures of iron pipe or masonry culverts or arches in existing lines. The writer knows of one railway which has profited greatly during the last year by the above use of the stadia.

While stadia rods and wires are such convenient instruments in the hands of a man who has had even a few hours drill in the use of them, it is surprising how slowly the rank and file of the engineering craft adopt them for everyday use. The writer recently went the round of the railway engineer offices in a thriving city of over 100,000 inhabitants—the terminal of several important lines—with the written request of an officer of one of the roads, to be lent a stadia transit for a short time.

In not one of these offices could it be learned whether such an instrument was in use on their line.

Telemeter.

Chicago, Feb. 23, 1901.

Repairing Chain-Tapes in the Field.

Sir: A number of good articles have appeared in Engineering News regarding the repair of broken steel tapes in the field, but none of the methods described are applicable to the chain-tape which is so extensively used on city, bridge and railroad work. This style of chain is made of a thin ribbon of steel the same as the steel tape. They are from 100 to 500 ft. long and subject to rougher handling than the ordinary steel tape receives.

It is a well known fact that a break never happens at the doorstep of a repair shop. On railroad work it invariably occurs several miles from a town, which is not only a great inconvenience, but a loss of valuable time; so the following simple, yet effective method, which is somewhat similar to the one used by the U. S. Volunteer Engineers during our late war with Spain, may be of interest to those using the chain-tape.

Secure a limb of a tree, or any round stick 4 ins. long and ½-in. in diameter, split it lengthwise, making two half round pieces. Across the flat side of one of the pieces and equidistant from the ends cut two notches ⅛-in. deep and ¼-in. apart. Take the chain and carefully bend

A Spliced Chain-Tape.

at right angles ¼-in. of each broken end; place these ends in the notches cut in one of the sticks so the graduations will read in regular order, then complete the splice by placing the flat side of the other half round stick against these ends of the chain to hold them in place, and bind the two halves together with stout cord or wire, as shown in the accompanying illustration. Trim off the ends of the sticks so they will offer no resistance in passing through brush, and the work is finished. In this way the writer has repaired broken chains in the field in fifteen minutes, which have held satisfactorily for several days, or until the work in hand was completed.

Yours very truly, W. S. Bastian.

Reading Terminal, Philadelphia, Feb. 19, 1901.

Concerning Correspondence School "Graduates."

Sir: "Chief Engineer" should not form his opinion of "graduates" from his limited acquaintance with freshmen, who are only doing their preliminary work, as he seems to have done by his letter in your issue of the 7th. A little consideration of the case of his acquaintance, who began his course last October and is now studying plane trigonometry, will show him there is nothing of the skyrocket order about this. Arithmetic was merely review work to the young man and plane geometry and plane trigonometry immediately follow arithmetic.

Now how much time does a college student put on plane trigonometry? Not more than four hours' recitation a week for three months. My college experience gave me plane and solid trigonometry, including surveying, navigation and accompanying frills in four hours a week for one year. But this young man has put in three months at least on plane trigonometry alone. His knowledge of its practical application ought to be accepted with confidence.

While in college I acquired a fair knowledge of mathematical gymnastics, most of which I have since forgotten. They were interesting puzzles. For practical application these higher branches must be reduced to the simplest form, and it is in this that the correspondence schools find their field. Their instruction books have eliminated nearly all theory and have made plain many simple mechanical formulae that would otherwise be buried under heaps of mathematical rubbish.

To thousands of men, opportunities are thus opened which would otherwise be closed, except to very few persistent and patient workers and to college men. Unfortunately, the seductive advertisements of these schools allure an occasional man who persuades himself that they have some patent method of injecting information into him without much work on his part. "Chief Engineer" seems to have found this sort of man. Who has not met men who were wise in their own conceit? There are indolent and sporty students in college and they eventually get degrees. Would "Chief Engineer" engage them on this account, or would he put to them the same questions he did to the correspondence school student? I know a graduate mechanical engineer who cannot read an indicator diagram with any confidence. There are also indolent and non-persevering students in correspondence schools, but the majority are doing their best for self-improvement.

Let us hope that "Chief Engineer" will find among his future applicants the energetic, persevering man, to whom these schools have been a great benefit. M. E. 20666.

Smith's Falls, Ont., Feb. 18, 1901.

A Scheme for Highway Improvement.

Sir: Seeing that your paper of Jan. 17, 1901, devotes a page and two-thirds to the Good Roads discussion now before the public, I thought: "Now I will get some good up-to-date information on this very important subject." I read and reread that article with great interest at first, but one clause after another wastes time and interest in the subject of roads. Not one of the writers in that article appears to realize that all good roads talk about "What my father did with four horses" is just so much waste

time. We are past the horse-power age and into the electric age, and any talk about main roads that don't include electricity as a motive power is away behind this age.

Further, they all speak of the road supervisor as if he were an absolute necessity, when, the fact is, he has been a curse to every person using the roads of Pennsylvania since his office was created. Here and there, there may be an intelligent man elected supervisor; but, as a rule, from the office. After 40 years' experience in traveling over the bad roads of Pennsylvania, I took a three months' trip over the good roads of Europe, and in no country did I find such stupid management as the Pennsylvania system of electing often the most ignorant and often the most drunken man in the township to road supervisor; and then to think of the Legislature of Pennsylvania annually placing four million dollars in the hands of such men to waste! I propose that the Pennsylvania Legislature enact a road law as follows: (1) Authorize the Governor to appoint an experienced road engineer to take charge of all the roads of every kind in Pennsylvania as chief engineer. (2) Authorize the chief engineer to appoint in each county a suitable person (who has stood an examination before a board of examiners) to be chief engineer of all roads in the county. (3) Authorize each county engineer to appoint an engineer in each township qualified as above, and thus have a complete chain of responsibility of qualified officers. Next have the state chief engineer authorized by law to order every county engineer to as soon as possible locate four radial roads running as straight as possible from his county seat to the four nearest county seats. These roads should be made 60 ft. wide so as to accommodate a double-track trolley line and have 15 ft. on each side for public travel and teams, and ditches 5 ft. wide and 3 ft. deep in the center where needed.

When any of these roads are so far completed that their total cost can be calculated, the state engineer is to give 20 days' notice of the time and place where he will sell at public auction to the highest bidder above cost the lease of that road, to be occupied for 20 years by a double-track trolley line to convey both freight and passengers. Thus the rent from the trolley line for twenty years will pay all the expense of making the road.

I think this system of road making will place Pennsylvania in the front rank. The making of such roads will give employment to every working man at extra good wages. It will also give working men a chance to have a home for wife and children in the healthy country air, etc. Yours respectfully, Arthur Kirk.

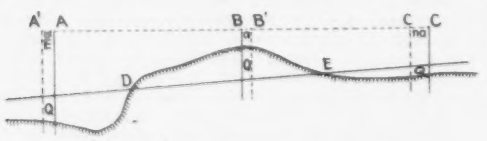
Pittsburg, Pa., Feb. 18, 1901.

(Would such franchises as our correspondent suggests be salable?—Ed.)

The Computation of Economic Overhaul.

Sir: It sometimes becomes necessary in computing overhaul, to find the point from which a cut will haul most economically in both directions. If the cut and the fills at each end were symmetrical within the limit of haul, the solution would obviously be to haul half of the cut each way. But as it often happens that the cut is deeper at one end than at the other, and the fills also are of different heights the general solution is slightly different.

The most economical haul is that in which the sum of the overhaul in both directions is a minimum. To satisfy this condition the proper location of the point of division is such that the extreme haul in each direction is the same. The method of finding this point is easy enough, being a simple problem in arithmetic, and does not need description. The method by which the writer arrived at, the rule given is also immaterial; it is only necessary to demonstrate the correctness of the rule.



In the figure, which may represent the profile of a cut D E and the fill at each end, let

Σ H = overhaul from B to A;
Σ H' = overhaul from B to C;
▲ B = B C = L.

Σ (H + H') is now a minimum; for, move the point of division a short distance, a to B', and let the excavation prism from B to B' = Q. The quantities from B' to D will now haul to A', a distance m a from A, and the overhaul from B' to A' will equal

$$\Sigma H_1 = \Sigma H + Q\left[L + \frac{a + m\,a}{2}\right],$$

a and m a being so small that the center of gravity of Q is in the center of the prism.

Similarly, the quantities from B' to E will now haul to C', a distance n a from C, and the overhaul from B' to C' will equal

$$\Sigma H_1' = \Sigma H' - Q\left[L - \frac{a + n\,a}{2}\right];$$

$$\Sigma (H_1 + H_1') = \Sigma H + \Sigma H' + Q\left\{\left[L + \frac{a + m\,a}{2}\right] - \left[L - \frac{a + n\,a}{2}\right]\right\};$$

$$= \Sigma (H + H') + \frac{Q\,a}{2}(2 + m + n),$$

which is greater than Σ (H + H').

Yours truly, Geo. H. Tinker.

Div. Engr., B. & M. R. R.R.

Billings, Mont., Dec. 29, 1900.

(The above communication was printed in our issue of Jan. 31, but the diagram was omitted through an oversight. It is, therefore, reprinted. —Ed.)

The Howe Truss Brace Problem.

Sir: The following solution of the "Howe truss brace problem" is one which the writer has used extensively, and it is submitted hoping it may be useful to others.

Theory: In Fig. 1, let the length of the longer side of panel (generally the depth of truss between chords) = 2 h, and of the shorter side (generally the panel length) =

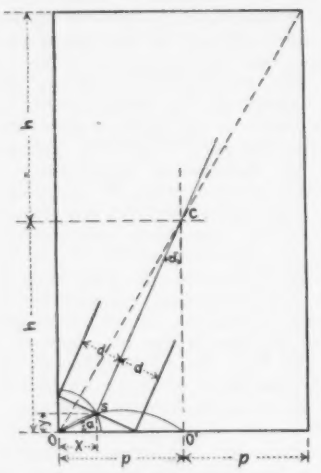


Fig. 1.

2 p. Let x and y be co-ordinates of the center of end (point s) of brace of width = 2 d. With h and p variable and d constant the point s will describe a circle of radius o s = d about the origin o.

$$x^2 + y^2 = d^2. \qquad (1)$$

With h and p constant and d variable the point s will trace the curve o s o', the equation of which is derived as follows: By geometry the angles a and a_1 are equal. But $\tan a = \frac{y}{x}$, and $\tan a_1 = \frac{p - x}{h - y}$. Equating

$$\frac{y}{x} = \frac{p - x}{h - y};$$

$$\therefore\ h\,y - y^2 = p\,x - x^2,$$

and if p is less than h

$$y = \frac{h}{2} - \sqrt{\left[\frac{h}{2}\right]^2 - x\,(p - x)}. \qquad (2)$$

Combining the equation of the circle (1) and of the equilateral hyperbola (2) analytically is a complex process and unnecessary in solving the values of x and y.

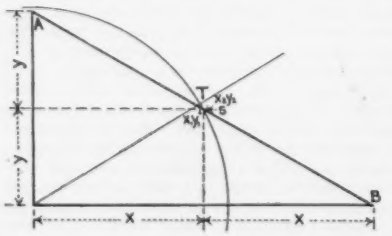


Fig. 2.

By inspection, Fig. 1, it will be seen that as the point s approaches the origin o (as width of brace decreases) the angles a and a_1 increase, and when s reaches o tan a = tan $a_1 = \frac{p}{h}$. That is to say, the equation of a straight line tangent to the hyperbola at the origin o is

$$y' = \frac{p}{h}\,x'. \qquad (3)$$

Plotting this line (see Fig.2) we know very nearly where the point s is on the circle (1). It will be just below and close to it. Then solving equation (3) for two values of x on either side of and near s will give, without appreciable error, the tangent to the hyperbola at s and the intersection of this tangent with the circle will be the point s.

Example: Let height of truss = 20 ft. clear between chords; panel length = 12 ft.; width of brace = 14 ins.; then, reducing to inches, h = 120, p = 72, d = 7. With o as origin plot circle (1) with d as radius, full size also lay off tangent, equation (3), intersecting the circle at T. The point s will lie a little below T on the circle. Assume $x_1 = 6$, then, equation (2), $y_1 = 60 - \sqrt{3,600 - 396} = 3.40$. Assume $x_2 = 6¼$, then equation (2), $y_2 = 60 - \sqrt{3,600 - 410.94} = 3.52$.

Plot x_1 y_1 and x_2 y_2; connect with line intersecting circle at s. Then, by scale, x = 6.09 ins, y = 3.45 ins. A s B is face of angle block. Length of brace is

$$2\sqrt{(h - y)^2 + (p - x)^2} = 22 \text{ ft. } - 3¾ \text{ ins.}$$

Very truly yours, Albert L. Fitz,

Portland, Ore., Jan. 3, 1901. Engr. Pacific Bridge Co.

Notes of Experience in Driving the Cascade Tunnel.

Sir: In reading in Engineering News of Jan. 10 the excellent résumé of the work of driving the Cascade Tunnel on the Great Northern Ry., by Mr. John F. Stevens, the Chief Engineer of that line, it occurs to me that now is the proper time to study the lessons which were learned there. As superintendent of construction under Mr. Stevens during the first nine months of the work, all tunnel men will agree, that my opportunities for making and seeing mistakes were of the best.

As Mr. Stevens has stated we had at the start hard rock at the east portal and soft ground at the west portal. This soft ground was a mountain slide and extended for some 800 ft. It consisted of rock masses, boulders, gravel, sand and water. The material stood at its angle of repose. It would start to run when disturbed in the least. The contractor for grading the approaches had left a good bench on which to rest the first wall plates. We timbered it as shown in Fig. 5 (see Mr Stevens' article), "Tunnel section through soft heavy ground." We used but the outer set of timbers at the start. It seemed to me that we were in danger of having the first timbers "kicked" out by the moving material before there was sufficient side friction on the timbers to equal the thrust from the front. To prevent this, longitudinal sills were used under the posts. Under these sills, and lying in trenches carefully cut in the floor of the tunnel, were cross sills extending clear across the tunnel and about 4 ft. apart. The longitudinal sills extended out from in front of the first pair of posts a distance equal to the height of the posts. Then from the top of the posts 45° angle braces were run to the long sills. Two other, shorter, parallel braces were cut in below the long braces. Some evidences of load were shown by the timbering but the first pair of posts remained plumb. Each set of segments when put in was heavily blocked against the last set preceding. The sets of segments were put up well out into the air and dirt piled on the lagging to give weight and to shelter the men from rocks they loosened from the slope over the portal. When the heading had advanced about 40 ft. into the mountain at the roof line, a movement began and in six hours the segments were all tipping out from the portal. Raking, or ground braces were put in. These were trees cut long enough to put a pair of these braces, one from each end of a middle segment to the middle sills on which the vertical posts rested at a point some distance outward from the middle segment which was being braced. These braces carried the thrust to the ground. At later dates the same tendency of the segments to tip outward was seen and the same effectual remedy used. This plan was hit upon by George Fry, of New York city, then general foreman at the west portal.

While driving through the mountain slide at the west portal there was great trouble from the volume of water. Mr. Stevens is very kind to say that during April, 1898, the progress was less than 1 ft. per day. It was 25.5 ft. in 30 days. During the week ending November, 1897, we drove but 2 ft. of tunnel in the seven days. The flow of water by weir measurement made by Mr. Reed at the time was 1,000,000 gallons of water in 24 hours. The flow was constant from October, 1897, until the writer left there in May, 1898. The rains and melting snows were an unending source of supply. The ground was open. The water came down everywhere in streams. It used up our men who were experienced and new men did not come to learn to take their places. We tried every device we knew. The volume of the water we could not combat. It is my duty to say now that the only measure that aided us was a bottom drift proposed and successfully driven by one of the heading men named Foley, if my memory be correct. He believed that if a drift was worked forward along the floor of the tunnel that the sloping rock ahead would tend to throw a large amount of the water into that drift at the floor level and that less water would fall from the roof. He was right. Like the cooper who used a draw shave in the putty-like material at the Sarnia-St. Clair Tunnel, Foley solved our problem. The flow from the entire tunnel remained a constant by the weir. The fall

of water from the roof was much less. Mr. Reed will recall that my opinion then was, that this man should be given credit, when any account of that tunnel was written, for the best idea any of us had in that problem at the west portal.

The bottom drift was kept most advanced. Next came the top drift which was made wide enough for placing in position the middle segment of the outer (longer) set of timbers and high enough to set them 1 ft. above their grade height. We used the poling board and double cap method of driving and timbering both the bottom and top drifts. The middle segments were themselves no part of the top drift timbering but were put in some 6 ft. back of the front of the top drift. In the Cascade Tunnel the five segments forming a set were of the same length. All were alike and interchangeable except that the lower ends of the bottom segments had crow feet cut in them where they rested on the wall plates. This feature of equal lengths of segments was introduced there by Mr. C. P. Smith, the engineer at the tunnel during the first ten months of the work. It saved care and watching.

The haunch segments, abutting on each end of the middle segments gave us most trouble of any of the segments. In that heavy flow of water the pitch of this pair of segments made it hard to hold the dirt over them. We used baled hay held up by blocking and plenty of braces. Shallow side drifts were next driven and the wall plates run in. These were set at varying heights above grade. My recollection is that Mr. Smith finally used 6 ins. Not only the settlement but the undermining of all timbers by the flowing water must be provided against. One of the most important points to be watched was blocking hard with heavy blocks and good wedging behind or outside the wall plates for their entire length. By this plan only could the roof timbers be kept from spreading.

At the east portal no bench was left by the contractor taking out the approaches. At first every shot blew down our scaffolding. Later we drove the segments back so hard by our shots that we broke a fir tree 24 ins. in diameter, which we had lowered and laid back of and against the first top segment. The rock drilled hard, shot well, and after 30 days' exposure to the air stood badly. Owing to the fact that Mr. Hill wished the tunnel started as well as finished as soon as possible we began the east portal heading with hand drills. We were four months getting power drills started. Meanwhile the heading was some 325 ft. ahead of the bench. This east portal had a descending grade going into the tunnel of 1.7%. There was some water. It was at the front, and the drillers stood in it. The muck could not be wheeled so far and be kept clear. We pushed it up that grade in cars to the bench and then dragged it to the dump with horses, as we had no power. In my judgment, it was a mistake to use hand drills at all, and it was worse than useless to do so for four months. That heading, some 300 ft. ahead of the bench, was a millstone about our necks. The heading had to stop or the tunnel must drag in its progress. The former plan was partially followed during May, June and July, 1898, and the heading and bench kept together afterwards. Superintendent Andrews deserved commendation for this. That a long heading overtaxes transportation and retards the progress of the entire portal, was one of the lessons to be learned from the driving of the Cascade Tunnel.

Among the innovations may be mentioned four columns used in a heading at one time on which six drills were used simultaneously. We believed this to be new at the time. The extra columns were set outside the usual pair and on line transversely. We moved no columns in drilling one set of holes. There was enough room for the six drill runners. Another idea that proved a good one is shown in Mr. Stevens' article. This is the derrick for loading large stone and saving block holing. It is shown in Fig. 5 in modified form. At first, and as designed and built by James McAtee, the general foreman at that time at the east portal, it was a small swinging derrick resting on the end of the side sill of the traveler.

The dynamite was thawed by conducting live steam from the boilers to coils of pipe in small thaw houses located some distance from the boilers in the power houses. The thaw house is shown at the west portal, but not at the east portal. In winter the steam became hot water by the time it reached the thaw house.

The ventilating apparatus could be made to blow good air into the heading or to exhaust bad air from it. Experience at first showed that the latter plan gave earlier relief and enabled the men to go back sooner after firing a round of holes. Opening the air hose on the floor of the heading wall to the front of the muck pile, running the compressor at full speed and at the same time exhausting the air from the roof of the tunnel as near the front of the heading as possible, was the most efficient method. The long heading and the long snow shed taxed any method of quickly clearing the heading of smoke.

We were greatly annoyed by dynamite fumes in the heading. This was partly due to the long distance from the blasts to the pure outside air and partly due to the fact that eastern factories were not allowed to furnish and western factories could not then produce dynamite less harmful. These fumes injured the drill runners and helpers and knocked out the foremen so many times it used them up. The effect was somewhat like the "bends" in compressed air work, but it also poisoned the tissue of the lungs and had the effect of pneumonia.

Mr. Stevens has referred aptly to the kind of men offering themselves there for work as "birds of passage." They were a study of sociology—humor and pathos were blended. During my time one-third of the monthly pay roll, amount of $7,500, was handed back to me by the men to deposit in Seattle banks or send to their homes. We kept one-third of the men steadily—or as steadily as good men could stand the water at the one portal or the dynamite fumes at the other. It seems to me that one could see no farther into that human nature than into the front of those headings. Still, those men were all kind to me and did as they were told by me.

From a strict engineering standpoint the most gratifying fact is the remarkable accuracy of the instrument work. Knowing the circumstances, it impresses me as being wonderful. It has called the attention of civil engineers to the Cascade Tunnel. We would all like to learn more of the detail of the field work, and it is to be hoped that Mr. Stevens or Mr. Reed will place the field methods in detail on record. That the name of Mr. C. P. Smith, the engineer in charge of the construction of the tunnel for the first year was not stated, is clearly an inadvertence. All concede that his large experience in instrumental work in tunneling was most valuable. The methods he used were mature, although improvements by Mr. Reed in his later work were to be expected.

It is a great tunnel—the second longest railway tunnel in the United States. It was brought to a successful close. If was the brave project of a brave man, who financed it, believed in it and taught others to do the same. In conception, in plan, and in detail it attests to the character, courage, and determination of President James J. Hill, of the Great Northern Ry.

Willard Beahan.

Winona, Minn., Feb. 21, 1901.

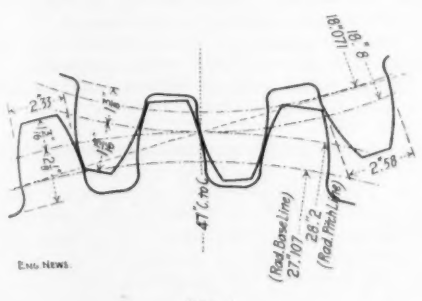


Fig. 1.

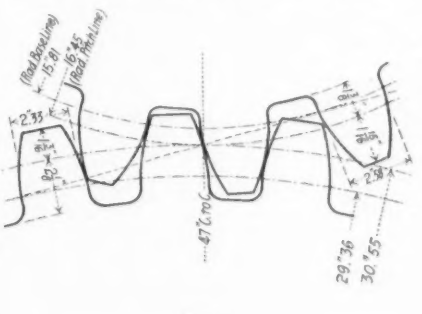


Fig. 2.

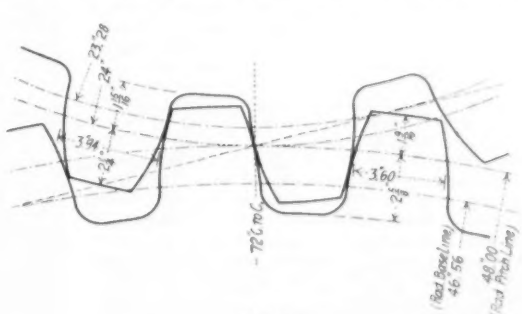


Fig. 3.

HIGH-SPEED TOOTHED GEARING.*

By James Christie.

For the transmission of power it frequently becomes necessary to use toothed gearing, subjected to high peripheral speed, conjointly with high pressure per unit of tooth contact, and the object of these remarks is to record what has been successfully done in recent years, as much higher speeds are now attained than formerly. Considered in a static sense, the gear tooth satisfies the condition of stress if it is proportioned to endure forces acting transversely on it, and the pressure per unit of contact is not of such intensity as permanently to deform the curved bearing surface of the teeth. When in motion, the curved surfaces slide upon each other as they enter and leave contact, and when this sliding action is accompanied with high pressure, the limit of endurance is soon reached, and in the case of inferior materials, this occurs at comparatively low speeds and pressures. In addition to this, more or less impact usually occurs, especially when the resistance is of a fluctuating character or the loads are suddenly applied. The effects of this hammering action are discernible by a flattening of the curved faces of the teeth, after which the proper engagement of the teeth ceases and the gear is speedily destroyed.

To prevent this, it is desirable to cut the teeth so accurately that no side clearance or "black lash" exists, and this is now usually done on first-class gearing of even the largest dimensions. Owing to the low elastic limit of cast-iron and the bronzes, we can not expect these metals to endure so high a pressure as steel, and steel appears to be the most trustworthy material to endure the highest pressures and speeds. This assertion, however, does not apply to all grades of steel. Soft steel surfaces abrade or cut very readily despite all methods of lubrication, and surfaces of this material should never be allowed to engage in sliding contact. Gearing of soft steel is usually destroyed by abrasion at quite moderate speeds. Rolling-mill pinions of steel, containing 0.3% carbon, have been destroyed in a few months, whereas the same pattern in steel of 0.6% carbon has done similar work for several years without distress. Of course, it is necessary to shape the teeth to a proper curve to insure proper engagement and uniform angular velocity.

Some years ago there was required suitable gearing to connect the engines to a rolling-mill in this vicinity. The diameters of the wheels were 37.6 ins. and 56.4 ins. respectively. They were intended to revolve at speeds of 150 and 100 R. P. M. and expected to transmit about 2,500 HP. The character of the service was such that renewal was a serious matter and long endurance very desirable. A high grade of steel was selected, especially in the pinion, in which the greatest wear would occur, and which, owing to the location, was the most difficult to replace. The pinion was forged from fluid compressed steel of the following composition: Carbon, 0.86%; manganese, 0.51%; silicon, 0.27% phosphorus and sulphur, both below 0.03%.

The spur wheel was an annealed steel casting: Carbon, 0.47%; manganese, 0.66%; phosphorus and sulphur, both 0.05%.

The tooth dimensions were: Pitch, 4.92 ins.; face, 24 ins. (Fig. 1.) These were accurately cut with involute curves generated by a rolling tangent of 16° obliquity. No side clearance was allowed. After starting the mill, it was found that a higher speed was practicable than was originally contemplated. Higher pressures on the teeth were also applied, so that ultimately about 3,300 HP. was transmitted through the gearing, corresponding to a pressure of nearly 2,100 lbs. per inch of face. The speed was variable, but occasionally attained a velocity of 200 R. P. M. for the pinion, corresponding to a peripheral velocity of 2,500 ft. per minute. This gearing has been in constant operation for several years, and behaves satisfactorily.

The highest recorded speed for gearing that I can recall is that described by Mr. Geyelin in the Club "Proceedings" of June, 1894. The mortise bevels had a peripheral velocity of 3,900 ft. per minute, but the pressure per inch of face was only about 680 lbs., the diameter and speed being made high to reduce the pressure on the teeth. I understand that the lifetime of these bevels is not long. If made of a grade of steel, as previously described, their diameter and speed could be considerably reduced, and prolonged endurance would be realized. About the same time No. 1 was installed a similar application was made to another mill, the gear having a different speed ratio, and the angular velocity being lower (Fig. 2). The compositions were:

	Pinion.	Wheel.
Carbon	0.80%	0.60%
Manganese	0.64%	0.64%

A much larger set had been previously employed, transmitting about 2,400 HP. at 750 ft. per minute peripheral speed, involving a pressure per inch of face of 3,500 lbs. This latter pair were 4 ft. and 8 ft. respectively, 7½-in. pitch, 30-in. face, cut with involute teeth of 14° obliquity (Fig. 3). The compositions were:

	Pinion.	Wheel.		Pinion.	Wheel.
Carbon	0.52	0.42	Phosphorus	0.222	0.078
Manganese	0.55	0.73	Sulphur	0.02	0.05
Silicon	0.107	0.279			

These gears have all rendered excellent service, and today are apparently as good as at the beginning.

As considerable expense is involved in cutting large gears of hard steel, it is sometimes practicable to rough-cut the gear after it is made as soft as possible by slow cooling, a higher degree of hardening being imparted before final finishing by air-hardening or rapid cooling from the refining heat. This is not infrequently done in the case of screws and gears of moderate dimensions. In this event it is desirable to have the ratio of manganese low, say not over 0.5% or 0.6%; as a high manganese con-

*Abstract of a paper read before the Philadelphia Engineers' Club, Dec. 5, 1900.

tent seems to impart a permanent hardness that is not readily reduced by slow cooling.

The subject of standard forms of teeth has recently become a matter of considerable interest, especially since the introduction of the electric motor, which has created a demand for accurate speed gear. Cycloidal curves so extensively used in the past seem to be less used in recent years than involute, for well-known reasons. The essential conditions required are that the osculating curves of the teeth must be normal to the point of tangency of the wheels throughout the arc of tooth engagement. Accepting the involute curve as a standard, it is desirable to adopt a uniform angle of obliquity for the generating tangent. The adoption of an angle of 15° by a prominent manufacturer of cut gearing and cutters has led to an extended acceptance of this standard. I will not enlarge upon this feature of the subject further than to observe that Mr. Hawkins, who was one of the early investigators of the merits of the involute form of tooth in the middle of the century, recommended an obliquity of 20°, and asserted that no practical inconvenience would be found from the resultant lateral thrust on the shaft journals.

When all other conditions are satisfactory, the flatter the curve of the tooth, the better, inasmuch as with a curve of long radius a higher pressure can be sustained than otherwise. With the ordinary straight tooth gear it is necessary to make the tooth of sufficient length, so that normal action never ceases between successive teeth. The wearing abrasion occurs when the teeth are entering and leaving normal contact. For this reason, for very high speeds some form of the stepped or spiral tooth would appear to be favorable, using a short tooth and a minute arc of engagement on the line of centers for each section of the tooth.

It appears to be practicable to maintain sliding surfaces of steel if one of the surfaces is hard, even if the other is comparatively soft, but for steel gearing for ordinary purpose I would suggest the use of steel not less than 0.4 carbon. If the speeds and pressures are unusually high, a much harder grade of steel becomes necessary. When a small pinion engages with a large wheel, the former alone can be made of high-grade steel approaching to a carbon content of 1%. When extreme speeds and pressures become necessary, the best results will be found by using in both wheels steel having a carbon content approaching 1%, or an equal hardness, obtained by lower carbon and high manganese or other desirable hardening addition. With gearing accurately cut from steel of this character and securely mounted, it is believed that reasonable endurance will be obtained when the product of speed and pressure, divided by pitch, each within certain limits, does not exceed 1,000,000: for example, a speed of 3,000 ft. per minute and 1,000 lbs. pressure per inch of face, or vice versa; for gear of 3-in. pitch, assuming, so far as we know, a maximum speed of 5,000 ft. per minute for gear of any pitch, and permissible pressure to be proportional to the pitch.

This statement that speeds and pressures are reciprocal, or as one is increased the other must be reduced, in a fixed ratio, may not strictly be a rational one, but in a broad and general sense it is correct within the usual limits of practice.

It will be understood that such a generalization as herein stated would apply to pinions having a liberal and not the minimum number of teeth.

DISCUSSION.

E. Graves.—Mr. Christie made reference to some gear wheels concerning which I wish to give some further particulars. These consist of three sets of cast-steel bevel-wheels, all duplicates. The pinions are the drivers, and are 57.39 ins. pitch-line diameter, have 36 teeth, 5-in. pitch and 20-in. face. The wheels are 74.8 ins. diameter, have 47 teeth of same face. The teeth are carefully cut to involute layout, and are 3.43 ins. high,—1.59 ins. above pitch-line, 1.84 ins. below pitch-line,—and 2 15-32 ins. thick on pitch-line. The normal speed of pinion is 260 R. P. M., giving 200 revolutions to the wheel, and nearly 4,000 ft. circumferential speed on pitch-line. The transmission is 1,300 HP. Assuming that the entire load should come on the outer end of one tooth, and was equally distributed along its length, the result would be 2,100 lbs. per sq.-in. fiber strain at the root of the tooth.

These gears have been in service for five years; their behavior, however, has not been wholly up to expectations. Their wearing power, in the sense of resisting abrasion, is satisfactory, but at different times teeth have been broken out. This breaking has been confined entirely to the pinion, and the nature of the break is the same in all cases, evidently beginning at the large end, cracking around the root, and following along the tooth. In some cases the break has followed more than half the length of the tooth and the piece has been thrown out; in most coses the existence of the crack in its early stages has been detected by the sound of the gear in action. The quality of the steel in castings is the ordinary commercial article. The widest variation in analysis observed is, in one instance: Silicon, 0.25; sulphur, 0.036; Phosphorus, 0.071; manganese, 0.74; carbon, 0.31, and in another: Silicon, 0.27; sulphur, 0.03; phosphorus, 0.032; manganese, 0.80; carbon, 0.23.

As is to be expected, the softer metal has resisted breaking the longer. In two sets of these gears the resisting work is of a varying nature with sudden and wide fluctuations; in the third instance the working is more constant. This variation of conditions does not seem to have influenced failure, as the teeth have broken in all the sets.

One of the practical difficulties in operating bevel gears of the nature described is the difficulty of holding them so that they will be in proper contact; longitudinal motion in either shaft throws them out of pitch. The most serious problem, however, is in securing and maintaining shafts so that the extended axis-lines of same pass through a common point. The effect of power transmission from pinion to gear is to put these axis-lines out of position, moving them in opposite directions and resulting in end contact of teeth and concentrated load instead of evenly distributing the load along the whole length of tooth. In this particular the question of maintaining bevel gears is decidedly more of a problem than that of spur gears. In this latter case small end motions of carrying shafts produce no effect, while the wearing of bearings is only the shifting of pitch-line, and, as it occurs slowly, it will, within reasonable limits, adjust itself.

As a matter of further interest, I will mention that in this same room with these gears are three other sets of bevel gear having cut-steel pinions and mortise wheel with cast-iron rims. The diameters and ratios of these—speeds, mountings and service—are practically the same as those described, but the transmission of power is 1,100 HP. instead of 1,300 HP. The pinions have 33 teeth, 5½-in. pitch, with 20-in. face, the teeth being planed down to 2¼ ins. thickness on pitch-line. The wheels have 43 teeth. These gears have been in service some seven years. None of the pinions has ever given way; the wooden teeth in the wheels, however, last only from six weeks to two months, an extra rim being kept on hand for refilling and replacing.

Wilfred Lewis.—In regard to the pressures carried by gear teeth, Mr. Christie seems to lay down a rule making the product of speed and pressure constant. This would reduce the load in proportion to the speed, and it seems to me an open question whether that should be adhered to or not. I do not think it has been demonstrated how the pressure of the teeth should vary with the speed. Some experiments, I think, should be made which would indicate that more clearly than has heretofore been done. It is interesting to note his remarks regarding the influence of the hardness of the metal upon the pressures carried, and instead of reckoning the pressure by the inch as so much per inch of face, it seems to me the pitch should also be included, because the face of a gear tooth is very much like a roller, and the pressure carried by a roller varies with its diameter as well as with the face. Some authorities seem to think that it should vary with the square root of the diameter; others directly with the diameter, and I am inclined to the latter opinion. If gear teeth are proportioned for strength, they are also proportioned for wearing pressure and surface to carry the load.

Mr. J. Christie.—The bevel gears described by Mr. Graves are very interesting and useful as a record. It is much more difficult to obtain satisfactory results with bevels than with plain spurs, as any deviation from correct alinement is fatal to correct tooth action in the former. In this instance, while speed is very high, the pressure on the teeth is comparatively low—about 750 lbs. mean pressure per inch of face. Thus the products of speed and pressure in relation to the pitch are considerably below the quantity assumed as a safe maximum.

Regarding the quality of the material, the manganese is too high. While steel of this composition would be moderately hard and wear fairly well, it would be somewhat brittle. It is not surprising to learn that some teeth gave way by fracture. If the relative proportions of carbon and manganese in the steel were reversed, it would be a much better material for the purpose.

W. Trinks.—I wish to call attention to an article on high speed gearing in the November and December numbers of the "Zeitschrift des Vereins Deutscher Ingenieure," 1899, by the chief engineer of the General Electric Co., at Berlin, Germany. The experiments show that there is no rule for the relation between pressure and speed; it depends upon accuracy: the load on the teeth may be the higher the more accurately the gears are made. A remarkable method of manufacturing gears was the outcome of the experiment. The curves are laid out on paper three or four times the size of the real tooth, reduced to proper size by photography, transferred on sheet steel, and etched in. Thus the highest degree of accuracy is obtained.

It was found that neither cycloidal nor involute curves gave the best results. Another curve was developed with a view to reducing the sliding motion between the teeth. The article contains very interesting diagrams on this point. By dividing the length of two working teeth into an equal number of parts, the amount of sliding action can be determined and the fact shown that it is reduced to a minimum by these methods.

Another thing shown by the paper is never to place a flywheel close to a gear. If possible, have a good length of shaft between. Slight inaccuracies in the pitch of the wheel require acceleration or retardation of the mass, and in order to do this force is needed. This force causes a hammering on the teeth which may break them; in other words, plenty of elastic material should be between the inertia masses and the gears. I feel pretty sure that all engineers will be much interested in the article; it is a valuable treatise on high speed gearing.

THE BILL FOR A NATURAL FOREST RESERVATION in the Appalachian region, commented on in our issue of Feb. 7, has been favorably reported by the Senate committee on Forest Reservations. The bill appropriates $5,000,000 and proposes a reservation covering about 2,000,000 acres, located in Virginia, the Carolinas, Georgia, Alabama and Tennessee.

THE NERNST LAMP PATENTS for the United States have been purchased, it is reported, by Mr. George Westinghouse. He has put several engineers and physicists, with the assistance of a corps of skilled workmen, at work at the problem of perfecting its details, and this, it is said, has now been practically accomplished.

COMMERCE OF THE SAULT STE. MARIE CANAL FOR 1900.

The commerce of the Sault Ste. Marie Canal for the season of 1900 has been set forth in a statistical report compiled under the direction of Lt. Colonel G. J. Lydecker, Corps of Engineers, U. S. A. As the traffic exceeded that of any previous year, a synopsis of this report is interesting.

The total east and west bound freight traffic amounted to 25,643,073 net tons; exceeding by 2% the traffic of 1899. The navigation season lasted for 7 months 28 days; and the average monthly traffic during this time was 3,232,320 tons. The American canal passed 23,607,354 tons; while the Canadian canal passed 2,035,719 tons; or, the American canal, in 1900, passed 92% of the freight and 62% of the passengers, as compared with 8% and 38%, respectively, for the Canadian canal. During the season 19,452 vessel passages are credited to both canals, as against 20,255 for 1899. The total lockages numbered 10,685, or 314 less than in 1899.

The east-bound freight amounted to 20,532,493 tons; 17,604,773 tons of this going to Lake Erie ports, and consisted chiefly of ore, wheat, flour and grain. The west-bound traffic aggregated 5,110,580 tons; 4,890,938 tons coming from Lake Erie ports, and made up largely of coal and general merchandise. The estimated total value of all freight passing through the St. Mary's Falls Canal in 1900 is $267,041,950. In this valuation iron ore represents $61,663,380; general merchandise, $54,139,700; copper, $39,319,800; wheat, $28,342,511; flour, $27,042,752; lumber, $15,009,241; grain, $14,071,953, etc. The sum of $24,953,314 was paid for carrying this freight over an average distance of 825.9 miles with total mile-tons of 21,179,229,014. This is equivalent to a cost per ton per mile of 1.18 mills; and an average cost of $0.97 per ton for freight transportation. Some of the unit rates paid for freight for the distance noted were as follows: Coal, per net ton, 44 cts.; flour, per barrel, 12 cts.; wheat and grain, per bushel, 2 cts.; iron ore, per net ton, $1.05; copper, per net ton, $1.60; lumber, per M. ft. B. M., $2.30; pig-iron, per net ton, $1.50. These rates, as a rule, were less than those of 1899; though the rate on iron ore was raised from 70 cts. per ton in 1899. A table given shows that the average cost per ton-mile has decreased since 1887, when it was 2.3 mills. In 1894, however, it was 1.1 mills; 1.14 in 1895; 0.99 in 1896; 0.83 in 1897; 0.79 in 1898; and 1.05 mills in 1900.

The American vessels using the canal are classified as follows:

Class.	No.	Value.	Registered tonnage.	Freight, tons.	Passengers.
Steamers	515	$54,172,989	637,347	18,940,603	24,789
Sailing	296	11,943,594	281,816	5,909,383	.....
Total	811	$66,116,583	919,163	24,849,986	24,789

In addition to the above unregistered American craft carried 46,237 tons of freight in 364 passages. The registered vessels had the following beam and length over all:

Length.	Beam.	No. of vessels.
Up to 100 ft.	From 6 to 24 ft.	82
From 100 to 200 ft.	" 22 " 38 "	320
" 200 " 300 "	" 30 " 42 "	285
" 300 " 400 "	" 38 " 48 "	136
" 400 " 500 "	" 45 " 53 "	56

A table given for single cargo tonnage shows that 357 vessels in a single trip of each carried a total of 1,422,175 net tons. The maximum record for the season was 8,462 tons carried in a single cargo by the "John W. Gates," of the American Steamship Co., and this steamer made 154,551,378 mile-tons in the season. The barge "Madeira," of the Minnesota Steamship Co., carried a single cargo of 8,206 tons. The maximum single day traffic on the canal was June 4, 1900, when 219,364 tons of freight passed through on 125 vessels, with a total registered tonnage of 171,707.

The depth of water in the lake channels permitted a safe draft of 18 ft. during the season; and the record shows that the American vessels averaged 1 h. 10 m. 59 s. in passing the canal, including time expended in waiting for lockage and passage through. The canal is 1.6 miles long.

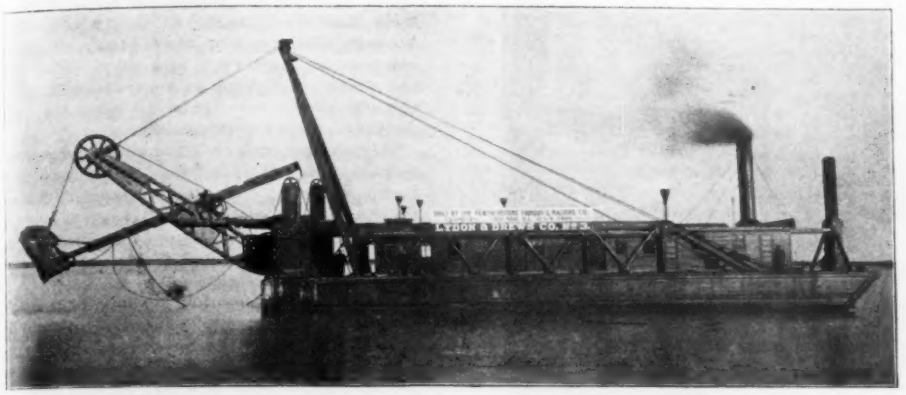


FIG. 1.—DIPPER DREDGE WITH 8-YD. BUCKET.

Built for the Lydon & Drews Co., Chicago, by the Featherstone Foundry & Machine Co., Chicago.

THE ISTHMIAN CANAL FROM A MILITARY POINT OF VIEW.*

By Col. Peter C. Hains.†

An isthmian canal to be of service to the United States presupposes that passage of it, through it and from it is assured. But passage to or from it in case of war with a strong naval power could only be maintained by a strong naval force. If the canal bristled with guns from one end to the other it would be of no use to the United States while a powerful hostile foe dominated the Caribbean Sea. The nation that controls the adjoining seas will, in time of war, control passage through the canal, no matter which one has possession.

The canal will be located in a region that is practically uninhabited. A few resolute men could disable it with little danger to themselves. This danger of being temporarily disabled is a serious one even in a war with a weak naval power. The destruction of a lock or embankment, which could be accomplished with a few pounds of dynamite, would bring about a total suspension of navigation for an indefinite period.

From a military standpoint the canal is valuable only as a shortened line of communication. It has no other value. It does not serve as a good base of operations in a war with a strong naval power. It occupies no threatening position in a war with Great Britain. No prudent naval commander would hold a fleet in Lake Nicaragua or Lake Bohia to spring out on the foe in either ocean, as has sometimes been suggested. If our enemy be weak, it would not be necessary; if strong, the dangers of being bottled up are too great. The canal is simply a link in a chain of communication. No chain is stronger than its weakest link. Forge it as you will, the weak link in a war with a stronger naval power than ourselves is on either side. Munitions of war and troops would ordinarily be transported across the continent by rail, as that is a more expeditious route. As a line of communication it is badly located when considered in a war with a superior naval power. Instead of being in a protected position behind the main line of defence, it is out beyond the skirmish line.

An adequate defence of a fortified Isthmian canal can be made in no other way than by providing a navy of sufficient power to control the seas at either terminus. With such a navy at our command the canal needs no fortifications. What number of battleships, cruisers, etc., would be necessary to accomplish this end we do not feel competent to estimate; that is a question for naval experts to determine.

Suppose, on the other hand, the canal were neutral. It would not then become a prize of war. Neither the maintenance of an army to protect it nor of a fleet to keep open communication with it would be necessary. Great Britain might possibly send ships through it, but even that is doubtful. The most that could be gained by doing so is a saving of time. Under some circumstances this might be an important matter. But the naval preponderance of Great Britain is such that time would be of less importance to her than to us. It is scarcely probable that it would ever be so important to her as to justify her in taking the risk of sending a fleet through a canal under American control.

From a military standpoint the canal is of more value to the United States than to any other nation. To keep it and the approaches open at all times would therefore be the aim of our government. But no amount of fortifications along the line of the canal will afford safe passage to a ship across the Caribbean Sea.

It is believed, in consideration of the freedom of the canal extended by the United States to the ships of all nations, those nations would agree to an arrangement by which the regions of the canal and large areas of the sea at each treminus should be exempted from the operations of war. The larger these areas of neutrality the better. But in view of the benefits to mankind which the United States would confer by the construction of the canal, there ought to be no serious difficulty in securing areas of the sea bounded by arcs of circles described with radii of say, one hundred miles or more. Should such an agreement be violated by any nation that is a party to it, the United States could destroy the canal if necessary, so as to render it impossible of being used against us. As no nation except Great Britain would wish to use the canal for any other than peaceful purposes of commerce, and as she probably would have no strong reason for using it in any other way, it is not seen why such an agreement might not be made. How such a status of the canal and adjacent waters can be effected are matters for statecraft to settle. The object of the foregoing remarks is to endeavor to show that a neutral canal, with a large area of neutral waters at each terminus, is, in the existing status of the naval powers of the world, a more useful canal to the United States from a military standpoint, than one that is controlled by military power.

*Extract from an address before the American Academy of Political and Social Science, Feb. 19, 1901.

†Corps of Engineers, U. S. A.; Member of the Isthmian Canal Commission.

A LARGE SINGLE-ROPE DIPPER DREDGE.

One of the largest dipper dredges on the Great Lakes, and probably the second largest in existence, has recently been built and put in service at Chicago, being intended specially for work on the Chicago river and harbor improvements. It has a wooden hull, strengthened by steel trusses, and the built-up steel boom carries a dipper arm with a bucket of 8 cu. yds. capacity. The boom is guyed from an A-frame on pin bearings. A special feature of the operating machinery is that wire hoisting cables are used instead of chains and that a single rope is attached directly to the bail of the bucket, while in many dredges the rope passes round a sheave on the bail and returns back to the engine. This dredge ranks a close second to the somewhat similar machine described and illustrated in our issue of July 13, 1899, which carries a bucket of 8¼ cu. yds. capacity, and which was said to be the largest dipper dredge ever built.

A general view of the new Chicago dredge is shown in Fig. 1. The hull is 125 ft. long, 42 ft. beam, 12 ft. deep forward and 10 ft. deep aft; and it is built throughout of white oak and Oregon fir. There are two 14-in. longitudinal solid bulkheads, keyed with iron, extending the full length of the hull. The two bottom side strakes, 12×18 ins., with sister keelsons 12×14 ins., and the ten intermediary keelsons 14×14 ins., are all of oak. The floor timbers are of white oak, 8×14 ins., spaced 2 ft. c. to c. transversely, and dovetailed into the bottom strakes. The forward and stern backing beams (top and bottom) are of oak, 18×18 ins. The bottom planking, running longitudinally (or fore-and-aft), is 4 ins. thick; the sides are of 6-in. fir, with a wearing strake of white oak in the center, and the top gunwales are also of white oak, 16×16 ins. The bow planking is of 10-in. fir; and the stern planking of 4-in. fir. The deck beams are of white oak, 10×10 ins., running across the hull, and carrying the 3-in. deck planking. The sides, bow and stern are connected to top and bottom gunwale strakes by white oak stanchions, 8×8 ins., reinforced by 1½-in. rods and turnbuckles spaced 3 ft. c. to c.

Fig. 2 is a plan and elevation of the longitudinal steel trusses which strengthen the hull and carry the dredging plant. They are 114 ft. long and 20 ft. 6 ins. deep, spaced 24 ft. apart, c. to c.

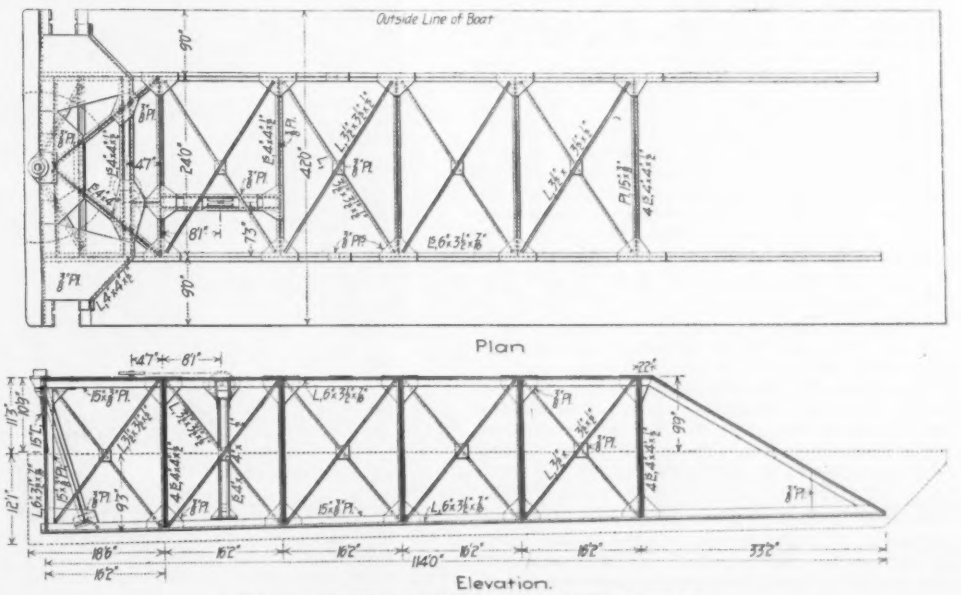


FIG. 2.—STEEL TRUSSES FOR DIPPER DREDGE.

The total height from the keel to the tops of these trusses is 23 ft. 3 ins. The top and bottom chords are each formed of a plate ⅝×15 ins. and two top angles 7-16×3½×6 ins. The posts are 16 ft. 2 ins. c. to c., built up of four angles ½×4×4 ins. and ⅜-in. filler plates. The bracing is of angle irons ½×3½×3½ ins., with ⅜-in. gussets and connection plates. The bottom chords are fastened to each floor timber by four clevis bolts, one on each side of each truss. A transverse chord, 15 ins. deep, connects the bottom chords of the trusses together at the bow. The top chords

are tied together at each post by built up members reinforced by large gusset plates, while there is also horizontal diagonal bracing of angles ½×3½×3½ ins. The front ends of the tops of the trusses are tied together by a portal bracing of built-up girders reinforced by large gusset plates, extending several feet back from the bow. Two diagonal struts fastened to the top cross girders run down and connect to cross girders at the bot

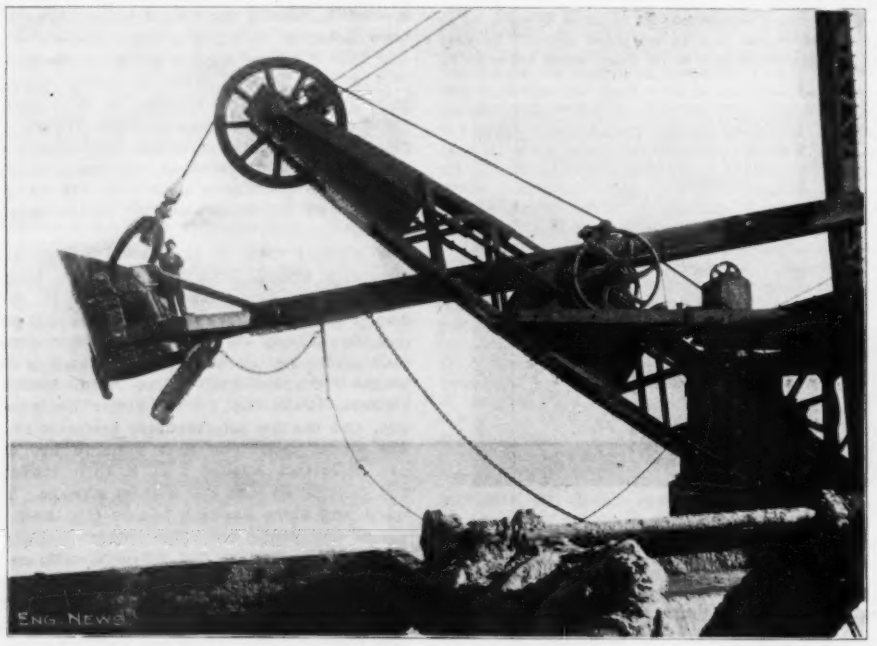


FIG. 3.—VIEW SHOWING BOOM, DIPPER HANDLE AND BUCKET OF 8 CU. YDS. CAPACITY.

tom chords of the trusses. This heavy construction is required to carry the boom and its attachments and to withstand the racking strains due to the operation of the dredge.

The A-frame and boom, shown in Fig. 3, are built-up steel members, with cast-steel fittings. The A-frame is 56 ft. high, its posts having three sides of 7-16-in. plates and angles, with lacing bars on the fourth or inner side. The section of the posts at the center is 24×24 ins. This frame is guyed by wire cables attached by turnbuckles to anchor bars near the stern. The boom is 48 ft. 9 ins. long, with a straight top chord and curved bottom chord, the depth under the dipper handle connections being 6 ft. It has a single 8-ft. sheave at the outer end and another 8-ft. sheave at the heel. Tangent to the latter is an 8-ft holding-down sheave under the deck. All the sheaves have turned grooves for a 2½-in. hoisting cable of plow steel. The overhead turntable is 20 ft. diameter, built of angles and plates. The 1½-in. swinging cables are of crucible steel and are gathered together by crosshead sheaves 3 ft-3 ins. diameter, passing down over leader sheaves of the same diameter to the drum of the swinging engine. This engine has double cylinders 10×14 ins., with valve gear of the link type.

The dipper handle is built up of two pieces of white oak, each 11×23 ins., 49 ft. long, and is reinforced on the sides by iron wearing plates. It is held in place by a yoke and sliding plates. The shaft of the dipper handle is 7½ ins. diameter, fitted at each end with a 6-ft. friction wheel. Two steel pinions of 3 ins. pitch gear with steel racks on the dipper handle. As the bucket shown is for digging mainly in soft mud and clay, it is fitted with a sharp cutting edge instead of teeth.

The main hoisting engine, shown in Fig. 4, is of very substantial construction, having the drum and gearing all self-contained in one pair of frames. It has two cylinders 17×20 ins. The main hoisting gear is 10 ft. diameter, 3½ ins. pitch, 10 ins. face, and power is applied to it by means of a steam thrust or clutch operating a friction band 8×1¼ ins., lined with maple blocks and provided with a convenient arrangement for taking up wear of blocks. This is shown in Fig. 5. A steam thrust is also provided for the check belt on the hoisting drum. An independent high pressure backing engine, with two cylinders 10×14 ins., is used in place of the old style of attachment to the hoisting engines. Steam for all purposes is supplied by a Scotch marine boiler 10 ft. diameter and 12 ft. long, provided with a steam drum of exceptional size. This boiler was built by Johnson Bros., of Ferrysburg, Mich.

There are three spuds; each of the two forward ones is a single stick of Oregon fir, 40×40 ins., 55 ft. long. The stern spud is of white oak, 24×24 ins., 55 ft. long. The forward spuds are each raised and lowered by an independent high pressure engine with two cylinders 10×14 ins., geared 62 to 1 by means of 2-in. crucible steel wire ropes. The rope for pinning-up the dredge passes over a large sheave on top of the spud. The dead end has an adjustable attachment fastened to the forward side of the spud castings. The rope for raising the spud is also attached to the forward castings and passes around a sheave in a slot close to the foot of the spud. The live ends of the ropes are attached to opposite ends of the drum of the spud engine. The stern or trailing spud is operated by means of 1-in. wire rope fastened to the bottom of the spud and passing over a sheave on deck, thence to the drum of an engine with two cylinders 7×12 ins., with valve gear of the link type.

The advantages of wire rope over chain on large dredges are now generally recognized, and a dredge of this size would require such a weight of chain as would be very unwieldy as well as costly. The advantages of the single hoisting rope over the three-part rope are that it does away with the dipper bail sheave and frame and the consequent bad bends resulting therefrom, thus prolonging the life of the rope. This single-rope dredge has a much greater speed of working. All the wire ropes of this dredge were supplied by the Macomber & Whyte Rope Co., of Chicago.

The cabin or deck-house is 95 ft. long, 22 ft. wide and 10 ft. high. In it are contained the kitchen, dining room, store room, sitting room, state rooms, bath room and office. The inside of the dredge is lighted by incandescent lights and the outside by arc lights, all operated by independent engines and dynamos.

This dredge was built by the Featherstone Foundry and Machine Co., of Chicago, for the Lydon & Drews Co., also of Chicago, for use in the harbors of the Great Lakes. The hull and general arrangement were planned by Messrs. Wm. Lydon, M. Am. Soc. C. E., and Fred Drews and Dennis McCarthy. Mr. A. Peterson, Yard Superintendent for the Lydon & Drews Co., superintended the building of the hull. The machinery was designed and construction superintended by Mr. Thomas Burgess, Superintendent, and Mr. Harry Gee, Mechanical Engineer, of the Featherstone Foundry & Machine Co. During a trial, working in sand and clay in 25 ft. of water, 385 cu. yds. (scow measurement) were excavated in 30 minutes.

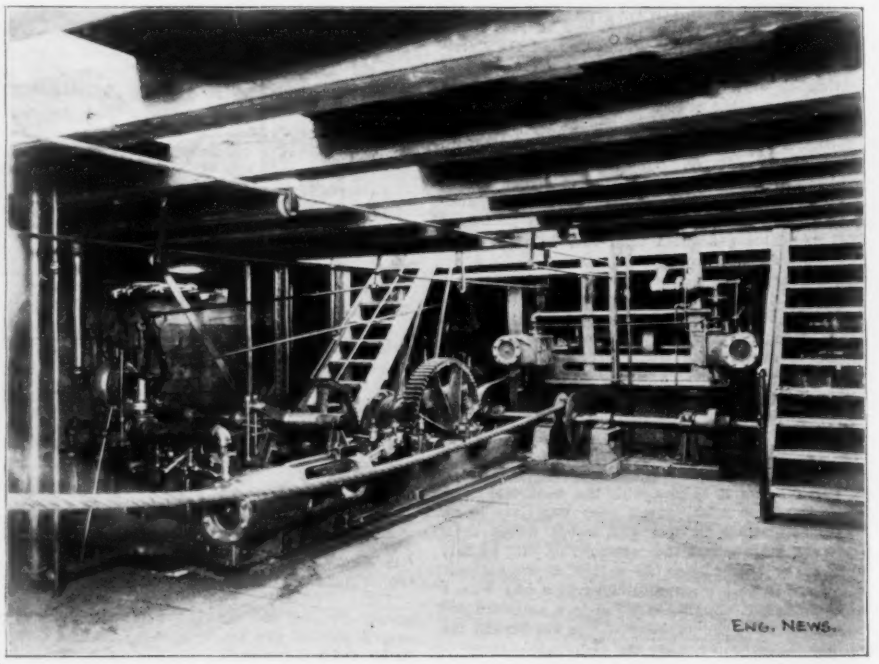


FIG. 4.—ENGINE ROOM OF DREDGE.

THE USE OF WATER IN IRRIGATION.

An interesting collection of papers on this important subject has been brought together by Mr. Elwood Mead, M. Am. Soc. C. E., and a number of other engineers and irrigators.* The report, which has been noted under "New Publications," emphasizes the fact that the irrigation problems of the day are largely administrative, although demanding much engineering assistance for their solution. There are two phases of the subject, however, which are essentially engineering: The distribution of water with a minimum of loss through seepage and evaporation and the measurement of the water applied to crops, as well as that which is lost in transit to them. To these

*Bulletin No. 86, U. S. Department of Agriculture, Office of Experiment Stations, A. C. True, Director. Report of Investigations Made in 1899 Under the Supervision of Elwood Mead, Expert in Charge, and C. T. Johnston, Assistant.

may be added a comparative study of the water needed by the crops and that actually applied, at least in so far as this may be deduced from records of water applied to the same crops on different farms, under conditions varying chiefly with the economical or wasteful application of the water. These three phases of irrigation come under the general head of the duty of water, which is commonly expressed in terms of acres irrigated per unit of volume of water, a knowledge of which is essential to every engineer who is called upon to develop and distribute water supplies or pass upon irrigation works, contemplated or in operation.

One needs to know but little of irrigation in the United States to be impressed with the general neglect of the duty of water in the filing or adjudication of water rights, and in contracts between water companies and irrigators. To illustrate this point, Mr. Mead cites an early adjudication of water rights on the Poudre River, in Colorado, where the quantity of water allotted to 1,000 acres was enough to water 41,520 acres on the low basis of a duty of 60 acres per 1 sec. ft. of flow. Of three contracts for water from the same stream the second entitled the farmer to 5½, and the third to 7½ times as much water as the first.

As to units of water measurement, Mr. Mead shows how the miner's inch is unsatisfactory for general use, even where scientifically defined. For gaging and dividing the flow of rivers and canals, or for continuous flows, 1 cu. ft. per sec. is the most satisfactory unit available, but in the best practice water is not used continuously in irrigation, and when it is, the volume may not be uniform. Contracts should be based on the total quantity used, both for fairness and economy of water. One important advantage of irrigation by rotation is that the water may be shut off that section of the canal where it is not being used, thus lessening evaporation and seepage.

Coming now to the field observations of 1899, Mr. Mead states that, besides securing facts relating to the character of the various irrigation works and records of rainfall and evaporation an effort was made in each case to secure as much information as possible on the following factors of the duty of water in irrigation:

The quantity of water required by different crops.

The length of the irrigation period in different sections of the arid region.

The agreement or divergence between the quantity of water used in irrigation in the different months of the growing season and the rise and fall of streams during those months.

The benefits of reservoirs and the percentage of the total discharge of streams which must be stored in order to utilize the whole supply.

Losses in canals from seepage and evaporation.

Influence of different forms of water-right contracts in promoting economy or waste.

The returns from the use in irrigation of an acre-foot of water.

A continuous, automatic water register was devised by Mr. Mead, giving the record of water levels on a natural scale, so any farmer or ditch rider could determine at a glance whether or not the instrument was working accurately, and if not, would be able to correct it without the computation necessary when a reduced scale is employed. The record paper is mounted on a cylinder, along which the pen or pencil is moved by clockwork. The cylinder is rotated by a cord passing over one end and attached to a float and counterweight. Weirs were used wherever possible, but in more than half of the cases where they were used the results proved that flumes would have been more satisfactory * * * due to the deposit of silt above them.

Sediment investigations made during the season showed that certain Southern streams carry, during floods, as high as 5% of solid matter in suspension, and that canals and laterals taking water from these streams have to be cleaned from two to three times each year. Even where the percentage was much less than this, the deposit of sediment was so rapid in some cases as to fill the lateral or ditch above the weir to a level with its crest in twenty-four hours. Where this happened the velocity of approach became a disturbing factor, the influence of which could not be determined owing to the constant change of conditions. Some canal companies which employ weirs operate in connection therewith a sluicing device which removes the accumulated sediment once each day, but the objection to this is that the conditions are never stable and it is impossible to tell for what length of time weir tables used agreed with the actual discharge. The recent investigations in the flow of water over dams and over weirs, other than those with sharp edges, may aid in securing the adoption of a form of weir better suited to the sediment-laden waters of the Southwest than that employed, but so far as knife-edged weirs are concerned there are few ditches in that section where it is not possible to secure rating tables for flumes which will give much more reliable and accurate results. It was also found that in a number of canals the grades were too small and the banks too low to secure the requisite fall below the weir, and in such cases flumes would not only be preferable, but an inevitable substitute.

The most serious objection to the use of flumes is the labor of preparing accurate rating tables, and the fact that a current meter is required for doing this. The recent improvements in these instruments, by which their convenience and accuracy have both been increased, has made it a simple matter to prepare a discharge table for flumes in which the flow is reasonably uniform. With ordinary care this discharge can be determined within the limits of accuracy permitted by the meter employed, and in the best instruments this error is as low as 1%. This margin of error is below what is permissible in the delivery of water or attainable in this investigation.

Measurements at canal head gates and at points of diversion to farms showed that seepage and evaporation often consumed as much water as was actually applied to crops, but that on the Gage canal, in California, which is narrow and deep, and has its sides and bottom cemented, the loss was only 6%. The general duty of water, including seepage and evaporation, ranged from 2.10 ft. in depth at Bozeman, Mont., to 6.26 ft. at Carlsbad, N. M., the irrigation period at Bozeman being from June 16 to Sept. 16, against the whole year at Carlsbad. For the same crops and with good construction and operation, Mr. Mead believes that the duty of water in the various States is very much the same.

The Cippoletti weir was the one generally used in this work. As none of the discharge tables for this weir were sufficient in range of length of crest and depth of water on the crest, Mr. C. T. Johnston computed new tables for lengths of 1 to 10 ft., and depths from 0.01-ft. to one-fifth the length of the weir, increasing by 0.01 ft. The formula employed was:

$$Q = 3.32\tfrac{1}{3}\ L\ h^{\frac{3}{2}}.$$

where Q is the discharge in cubic feet per second, L the length of crest in feet, h the depth of water flowing over the crest. A second table gives the discharge, under the same conditions, in acre-feet for two-hour periods. There are also similar discharge tables for rectangular weirs, with and without end contractions, and also corrections for end contractions.

Official Stations for Irrigation Investigations, U. S. Department of Agriculture; and Names of Observers.

State.	Location.	Observer.
N. J.	New Brunswick	Prof. E. B. Voorhees, N.J. Experiment Station.
Neb.*	Gothenburg	A. M. Allen.
	Lincoln	Prof. O. V. P. Stout, University of Nebraska.
Mont.	Bozeman	Prof. S. Forfier, Montana Experiment Station.
Wyo.	Wheatland	M. R. Johnston.
	Laramie	Prof. B. C. Buffum, Wyoming Experiment Station.
Colo.	Holly	Thomas Berry, Chief Engineer Great Plains Water Co.
Texas.	Beeville	S. A. McHenry, Texas Experiment Station.
N. Mex.†	Carlsbad	W. M. Reed, Chief Engineer Pecos Valley Irrigation Co.
	Mesilla Park	Prof. C. T. Jordan, New Mexico Experiment Station.
Ariz.	Phoenix	W. H. Code, Chief Engineer Consolidated Canal Co.
Cal.	Riverside	W. Irving, Chief Engineer, Gage Canal Co.
Utah.	Logan	Prof. Geo. L. Swendsen, Utah Experiment Station.
	Salt Lake City	R. C. Gemmell, State Engineer.
Idaho.	Boise	D. W. Ross, State Engineer.

*The State Engineer of Nebraska, J. M. Wilson, also cooperated with this investigation in the collection of data.
†Records of the duty of water at Aztec and East Las Vegas are also being furnished us by the New Mexico Agricultural Experiment Station.

As some of our readers may wish to know the location of the various government stations for the study of irrigation and the names of the observers, the accompanying table has been reprinted from the bulletin. Special reports are included in the bulletin from all the stations except those at New Brunswick, N. J., Gothenberg, Neb., Wheatland, Wyo., and Beeville, Tex.

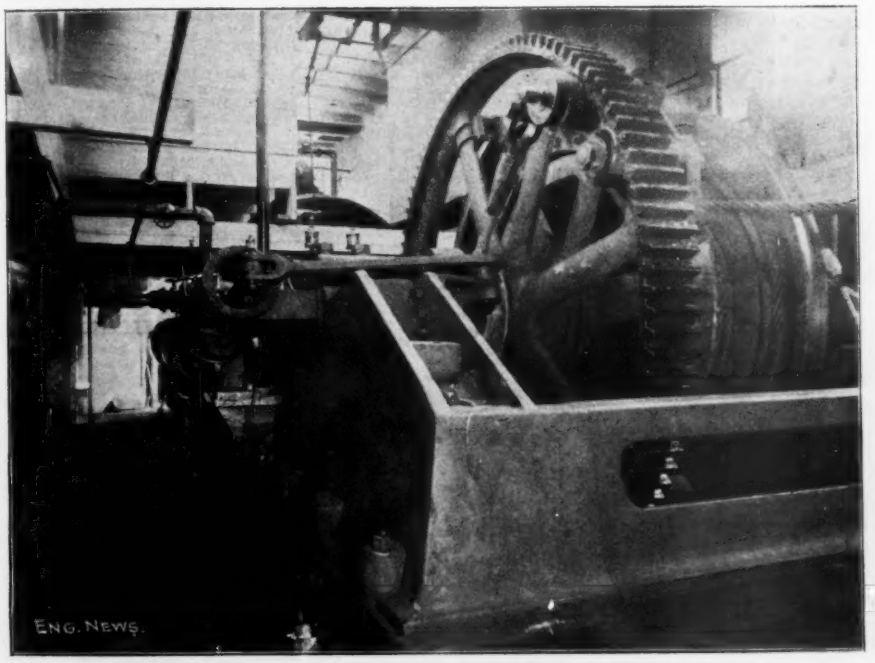


FIG. 5.—STEAM CLUTCH ON MAIN ENGINE.

EXPERTS' REPORT ON WATER PURIFICATION AT WASHINGTON, D. C.*

In accordance with your request we present to you herewith a report upon the purification of the Potomac River water for the supply to the District of Columbia.

This subject was investigated by Lieut.-Col. A. M. Miller, Corps of Engineers, U. S. Army, who, on March 28, 1900, made a report thereon to Gen. J. M. Wilson, Chief of Engineers, U. S. Army, which was printed as Senate Document No. 259, 56th Congress, 1st Session.†

In his studies Col. Miller gave attention to two processes for the purification of the Potomac water. One of these is variously known as American, rapid or mechanical filtration; the other, as English, slow or sand filtration. Colonel Miller recommended the adoption of mechanical filtration for the Washington water supply, the plant to be located near the new Howard University reservoir.

Exceptions were taken to this conclusion by a special committee of the Medical Society of the District of Columbia, which made a report, dated December 5, 1900, and printed as Senate Document No. 27, 56th Congress, 2d Session. This committee earnestly recommended the prompt installation of slow sand filters, on the ground that it considered them to be more reliable in purifying the water at all times, and, therefore, safer from an hygienic standpoint.

By direction of the Senate Committee on the District of Columbia, a hearing was held at the Waldorf-Astoria Hotel in New York city, on Jan. 4, 1901, as to the relative merits of the two systems of filtration for the water supply of Washington. At this hearing statements were made by a number of gentlemen familiar with the subject of water filtration.

At your request the undersigned proceeded to the city of Washington, inspected the pertinent parts of the water-works system and several sites available for filters, secured data bearing upon the problem, and conferred with

*Report made Feb. 18, 1901, by Messrs. Rudolph Hering, Geo. W. Fuller and Allen Hazen, Mems. Am. Soc. C. E., to Hon. James McMillan, Chairman U. S. Senate Committee on the District of Columbia.
†See Engineering News, May 17, 1900, for abstract of the report.—Ed.

officers affiliated with this branch of the District service. We beg to express our obligations to all of these gentlemen for the very courteous and efficient assistance which they have rendered us in our investigations.

The character of the raw water is often an element of controlling importance in deciding a question of this kind. Generally speaking, sand filters are best adapted to purifying waters that are not extremely turbid, and mechanical filters have marked advantages in the purification and clarification of waters which for considerable periods are very turbid. It was, therefore, necessary for us to examine all the available evidence regarding the character of the Potomac water.

At those places in this country where observations have been taken on the amount and character of turbidity of different river waters, the methods used have not everywhere been the same. To compare the Washington data, which cover a period of 23 years, with those concerning other waters, which have been studied in detail, we have converted them to standards with which we are more familiar, and have been able to compare the results with a reasonable degree of confidence. As a result of this study, we estimate that a million parts of raw Potomac River water contain, as an annual average, about 80 parts of suspended matter. For the purpose of comparing in general terms the character of this water with the characters of others which have been carefully studied, the following table, based on the best evidence now available to us, is presented:

	Parts per 1,000,000
Merrimac River, Lawrence	10
Hudson River, Albany	15
Allegheny River, Pittsburg	50
Potomac River, Washington	80
Ohio River, Cincinnati	230
Ohio River, Louisville	350
Mississippi River, New Orleans	500

In the purification of river waters, there are other very important factors to be considered besides the average turbidity or the weight of suspended matter. Most prominent among them are the fineness of the suspended matter during flood periods and the duration of periods of turbid water.

With streams where periods of turbidity are of short duration it is often possible at such times to close the intake, thereby avoiding the necessity of treating the most turbid water. The supply in the meantime must be maintained from storage reservoirs. We find that for Washington this procedure would not always be practicable, because the periods of highly turbid water sometimes last much longer than the period during which the supply could be maintained from the existing reservoirs, or from reservoirs which it is practicable to build.

We find that the water of the Potomac River at Great Falls, following heavy rains, is more turbid than any water which is successfully purified by slow or sand filters in this country. Few exact data regarding the turbidities of European streams are available; but it is certain that none of the waters filtered by the better known European sand filters approach, on an average, the turbidity of the Potomac water.

By subsidence it is possible to reduce materially the excessive turbidity of river waters by passing them through reservoirs. According to the best evidence now available, there are times when plain susbsidence of this river water for any reasonable period of time would not afford an adequate treatment preparatory to its successful purification by sand filtration. During some years this condition would not obtain, while during others subsidence might be inadequate for periods amounting in the aggregate to ten weeks and on an average to about one month each year.

It is further probable that the bacterial efficiency of the process might sometimes become inadequate, due to the general disarrangement of the filters caused by excessive turbidity. This condition would be less important at Washington than it was at Cincinnati. The water of the Ohio River at Cincinnati was found to be so turbid that it could not be adequately purified even after sedimentation, by sand filtration, for about 35% of the time. On this basis we estimate that at Washington the proportion of the time when sand filters alone would be inadequate would amount to about 8%.

As to the relative merits of the two systems of purification studied by Colonel Miller, namely, the treatment of plain subsided waters by sand and mechanical filters, his conclusion is correct, namely, that the latter system would be the more efficient and the more judicious one for the city of Washington to adopt.

Since his investigations were instituted, some improvements have been made in the general processes of both slow and rapid filtration. Relative to the former, this progress applies, for very turbid clay-bearing waters, to the use of coagulants, when needed. This procedure was studied at length at Cincinnati, and is used at a number of small places in Europe. It is referred to, in Colonel Miller's report, as the modified English system. It was not investigated by him owing to lack of funds, and in the absence of practical results he did not consider it.

Within the past few months material improvements in mechanical filters have been developed in connection with several municipal water supplies. These departures from former types of filters, in a measure, are made possible by the expiration of the Hyatt patent. In our endeavor to solve the Washington problem, we have devoted ourselves to a careful consideration of the relative merits of these two methods in their most improved forms.

We have based our consideration of the problem on a daily supply of 75,000,000 gallons of water, which approximates the present carrying capacity of the aqueduct. This amount is sufficient to supply all legitimate needs of a population much greater than the present one. Whenever a new aqueduct becomes necessary, the question of purifying the additional supply of water thus obtained will be a part of the new problem. In our opinion it is unnecessary now to consider the purification of more water than can be carried by the existing aqueduct.

In this connection we beg to call your attention to the large waste of water in Washington, and to suggest the advisability of taking measures to limit such waste. One of the most effective means of doing this is by the use of meters; and we recommend that they be placed on all public buildings at once, and on private services, when deemed necessary, as rapidly as practicable.

The question of deciding between the two systems of purification, with the improvements above indicated, is in some respects a difficult one. In character, the water for Washington is intermediate between the water for Pittsburg, where sand filters are best adapted to the conditions, and the water for Cincinnati, where American filters are preferable. If the Potomac water were more turbid, or turbid for longer periods than the records show, mechanical filters would unquestionably have the preference. If it were less turbid, or if turbid periods were of shorter duration, the advantage would clearly lie with sand filters.

Practical experience with sand filters is much more extensive and more favorable than that with mechanical filters. Our knowledge of what they will do rests not alone upon experimental investigations, but upon actual use for many years by some of the largest cities of the world. The force of this statement is somewhat reduced, however, by the fact that the raw water at Washington is more turbid than the raw water at the places where sand filters have been generally used.

Our knowledge as to the results that can be obtained by mechanical filters rests more upon experimental evidence than upon results obtained in practice. Nevertheless, these investigations have been made upon such a scale, and with such care, as to give the greatest confidence in their results.

It appears from consideration of the evidence at our disposal that the average yearly bacterial efficiency of the two systems would be about equal. During the warmer months of the year this efficiency would probably be greatest in the case of sand filters. When the river water is at or near the freezing point, the conditions upon which sand filters depend are less effective, and the efficiency of mechanical filters would probably be a little greater. This deterioration of sand filters would not be materially changed by covering them, as it appears to depend upon the temperature of the water while passing the filters, and this is not materially influenced by covers.

There will apparently be but little difference in the cost of the two systems. The cost of constructing sand filters is larger than the cost of constructing mechanical filters, but the latter are more expensive to operate; and when interest and depreciation charges on the investments are added to the costs of operation, the difference between the total costs is within the limits of accuracy of the two estimates.

After a full consideration of the various aspects of the problem, we are of the opinion that the long and favorable experience with sand filters, particularly in the light of the effect which they have had upon the health of the communities using them, should be given greater weight than the present evidence that American filters are able to give substantially equal hygienic efficiency. In view of the fact that there is no available evidence of decided advantage to be gained by adopting the newer method, we prefer in this case to adhere to the one supported by long precedent.

In regard to the exact site for filters, the short time at our disposal has not allowed us to make the necessary surveys and detailed estimates of cost, to decide definitely whether a site near the new Howard University reservoir, sufficient for the construction of filters to purify all the water that can be gotten through the present aqueduct, or a site beyond the District limits, and near the line of the aqueduct, large enough to allow almost indefinite extension, is to be preferred. The former site has this advantage: That filters constructed upon it would be at such an elevation that the filtered water could be supplied at a greater elevation than that which would be available from the Howard University reservoir. It may be found upon further study that this additional pressure will justify the somewhat greater cost of filters in this vicinity.

In consideration of the full evidence, we recommend the construction of a complete system of slow or sand filters, with such auxiliary works as may be necessary for preliminary sedimentation, and the use of a coagulant for a part of the time. There is no reason to believe that the use of this coagulant will in any degree affect the wholesomeness of the water.

AN INTERLOCKED CAST-IRON ARCH SOLID FLOOR FOR BRIDGES.

We illustrate in the accompanying cuts a solid floor made up of interlocking cast-iron arches which has been brought to our attention by Mr. A. H. Heller, formerly Chief Engineer of the Youngstown Bridge Co., of Youngstown, O., and now with the American Bridge Co. The floor is the invention of Mr. A. L. Wymer, of Youngstown, O., and as will be seen from the drawings, Figs. 1 and 2, the arches with interlocking edges are simply laid upon the supporting beams without riveted or bolted fastenings of any sort. The arches can be made of other material than cast iron, such as cast steel or terra cotta, but cast iron is considered the material most available and least expensive for general purposes. The following claims of merit for this construction are pointed out by Mr. Heller:

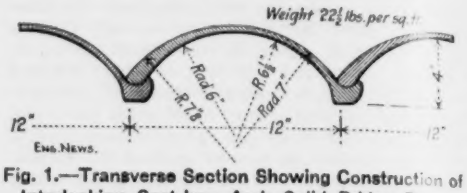


Fig. 1.—Transverse Section Showing Construction of Interlocking Cast-Iron Arch Solid Bridge Floor. A. L. Weymer, Youngstown, O., Designer.

The arches can be made of any dimensions to give the required strength and of such shape as to use most economically the metal in them. Cast iron being much stronger in compression than in tension, the strength of a floor-plate may be varied considerably by a change in cross-section of the plate with very little change in the weight; the fiber stress can be much more than doubled while the weight is decreased only 6 or 7%. Not only can the form of cross-section be varied or reinforced by ribs in various positions, but the span and rise of the arch should be varied to correspond with the work it has to do.

It will readily be seen, that even with a fiber stress much lower than is usually employed for cast iron, a section weighing much less than that shown in Fig. 1 would be adapted for use for bridge sidewalks and for floors of buildings. So far as dead weight is concerned, it would be much less than in hollow-tile construction. In a fire, tile floors fall after a comparatively small distortion of the supporting beams, thus allowing the fire to spread to the adjacent story. The cast arches would remain intact longer, in fact, until complete failure of the beams had taken place. These floor-plates are well adapted to be supported on shelf-angles between beams, on the top flanges of the beams, or on their bottom flanges, in tie rods are used, as shown in Fig. 2. There being no rigid connections between the floor-plates and the joists, and the floor being frequently at a different temperature from other parts of the structure, an adjustment would be possible, that would have an important bearing on the life of the pavement. Another advantage so far as the life of the pavement is concerned, would be the superior stiffness of the arched plates over buckled plates. Steel corrodes more rapidly than iron, and especially more than cast iron. Cast iron has, therefore, not only a longer life, but is cheaper in first cost than steel, and especially than steel in the special form for floors manufactured by but a few companies. It is believed that the simplicity of this form of construction, its adaptability to various conditions and its low cost will commend it to engineers and architects.

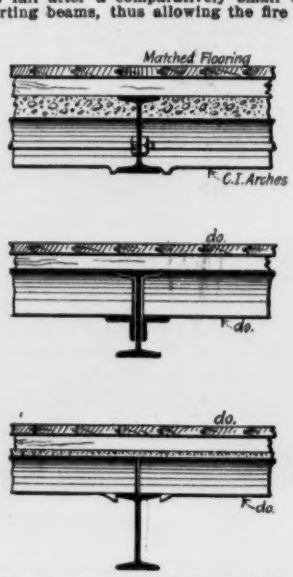


Fig. 2.—Sections Showing Method of Supporting Interlocked Cast-Iron Arch Plates on Bridge Floor Beams.